POWER

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Involuntary Servitude

WHEN a ship's crew mutinies and refuses to do the work for which its members have severally assumed the responsibility, it is a serious offense, punishable by the laws of all civilized nations.

A failure to perform their functions endangers the ship and all aboard of it. If they have a grievance, there are other ways of righting it.

When a country is in peril or wants to go on a marauding expedition and issues a call to arms, every qualified citizen must respond no matter how little sympathy he has with the movement. He must leave his family to shift for themselves, and for less than a laborer's pittance make his obeisance to a line of petty officers, undergo the most binding servitude under the strictest of discipline, and offer his breast to shot, shell and bayonet because of a common danger or to gain a common advantage. If he mutinies, he is "shot at sunrise."

But an organization of men who have assumed the responsibility of mining the coal upon which the industries, the transportation, the comfort and eventually the lives of the people depend, even to the extent of contending with force of arms against the right of anybody else to do it, and an organization of those who have been entrusted with a portion of the work of maintaining our national system of transportation have mutinied.

They have entered into a nation-wide conspiracy to hold up the rest of the country. Already their action has occasioned many deaths. Industries are paralyzed, the railway system is demoralized, train schedules are broken, locomotives and rolling stock are out of order, with all that these conditions involve in wasted time and increase of peril to the traveler, delay in shipments, the halting of the revival of business and the threat of famine in food and fuel.

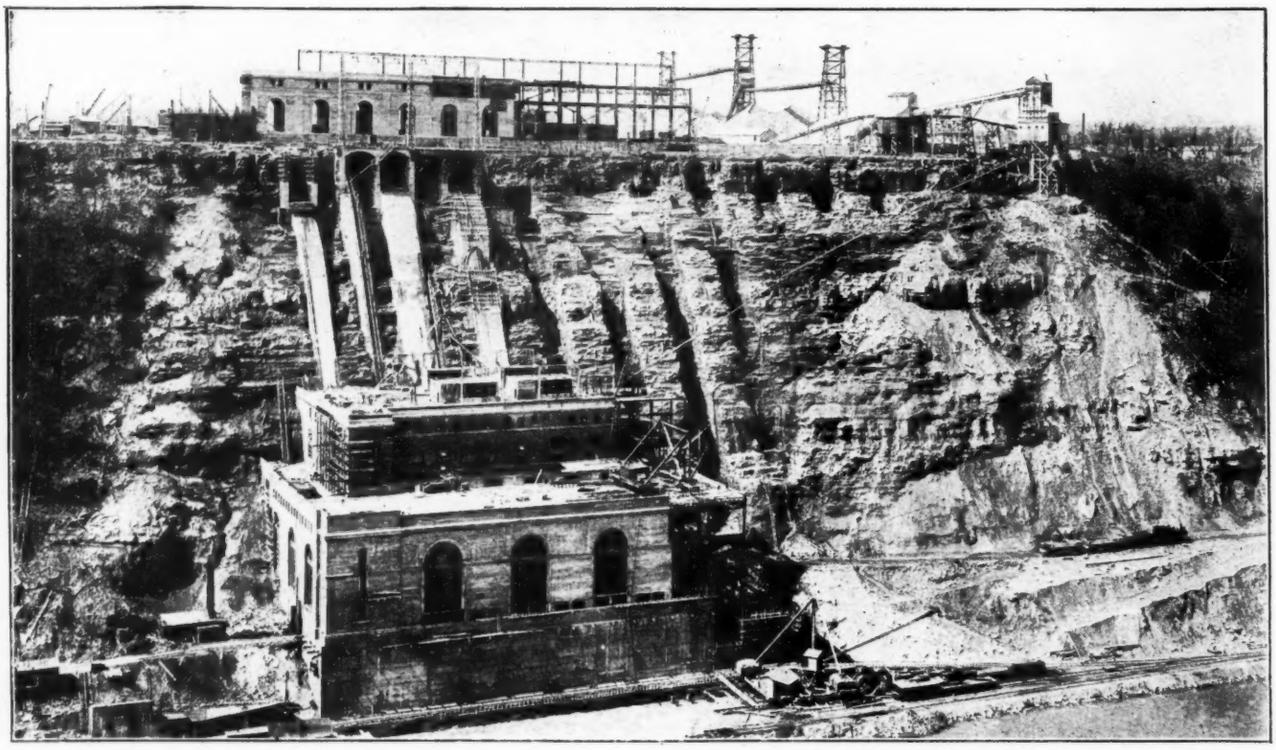
I yield to nobody in sympathy for the workingman. I believe that the man who is able and willing to work should be assured of a living and more. He should be relieved of the fear of unemployment, of a sense of servitude instead of co-operation, and be able with thrift to look forward to a comfortable old age

There is enough material and fertility in Old Mother Earth and enough available labor to win and convert it into an abundant living for everybody.

But I do not believe that the workingman or any other man or set of men has a right to upset the social and industrial system of the country and subject his fellow countrymen to loss and peril, at least upon any issue that has been made apparent as yet.

In the last analysis, against whom are they striking anyway?

F. R. Low



The Queenston-Chippawa 600,000-Hp. Hydro-Electric Station

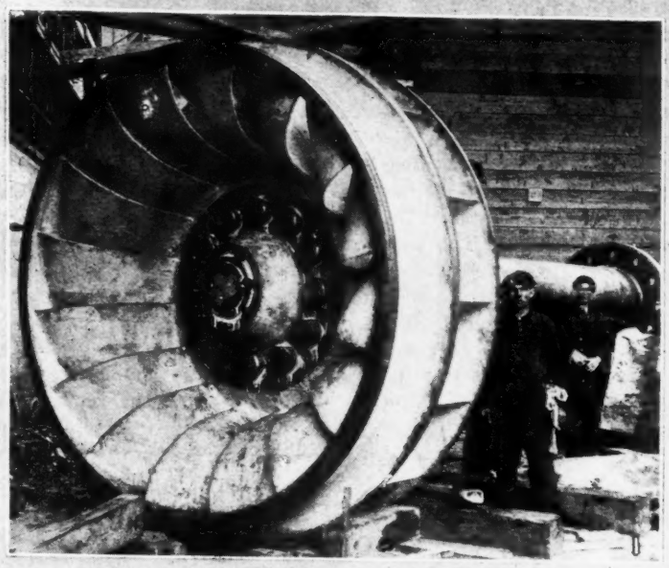
AS DESCRIBED in the June 27 issue, water for the Queenston power house is brought through a canal, designed for 18,000 cu.ft.-sec., from Chippawa, about two miles above Niagara Falls, to a forebay at the top of the cliff near Queenston—a distance of 13 miles. By so doing it has been possible to utilize at the power house 305 ft. of the 327-ft. fall between Lake Erie and Lake Ontario, and to develop 30 hp. per cu.ft.-sec. of water passing through the turbines. These figures are significant when compared with the plants at the Falls which operate under heads varying from 140 to 215 ft. and develop from 11 to 22 hp. per cu.ft.-sec. of water delivered to the turbine.

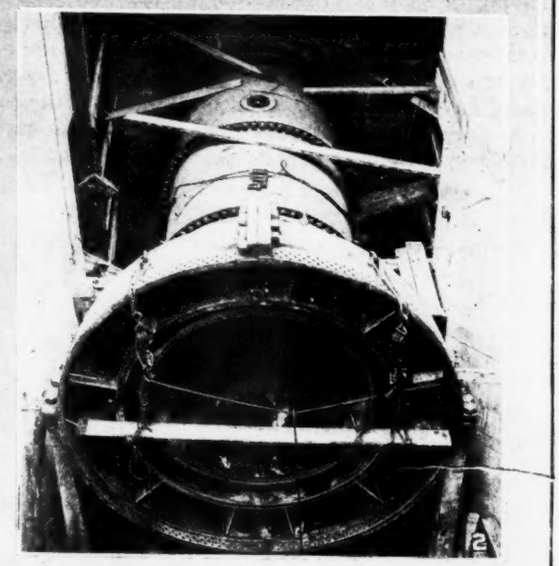
The headworks for the Queenston plant are laid out for 9 main penstocks, a penstock for the service units and an ice chute, and are arranged so that an entrance for a tenth main unit penstock may be added at the north end. A spillway 300 ft. long is provided in the forebay to reduce the maximum surge that may occur in the forebay in the event of a sudden shutdown of the power house, and effect a return to normal conditions in the forebay sooner than would otherwise be the case. The normal water level in the forebay, as can be seen in Fig. 6, is at elevation 550, and the top of the spillway has been placed at elevation 564.

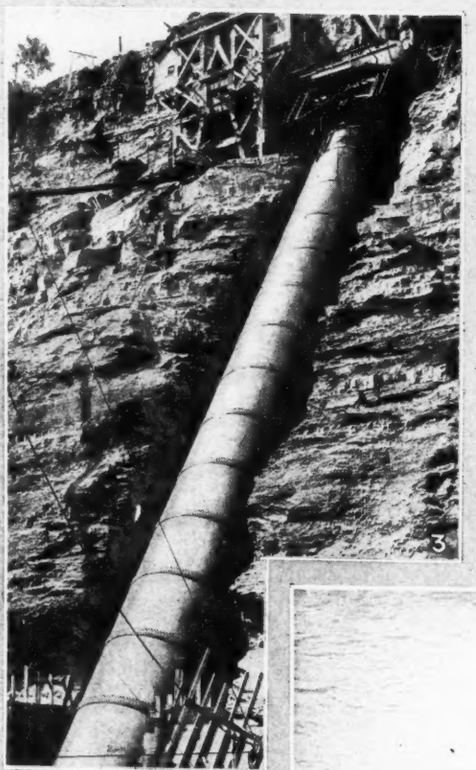
The plant will ultimately have a capacity of 550,000 to 600,000 hp., but at present five 55,000-hp. vertical shaft units are being installed. Two of these machines are in operation and have carried a maximum load of 64,000 brake horsepower. It is expected that the remaining three units will be in service by the end of the present year. To complete the installation 4 more units of considerably larger capacity than the present machines will be installed.

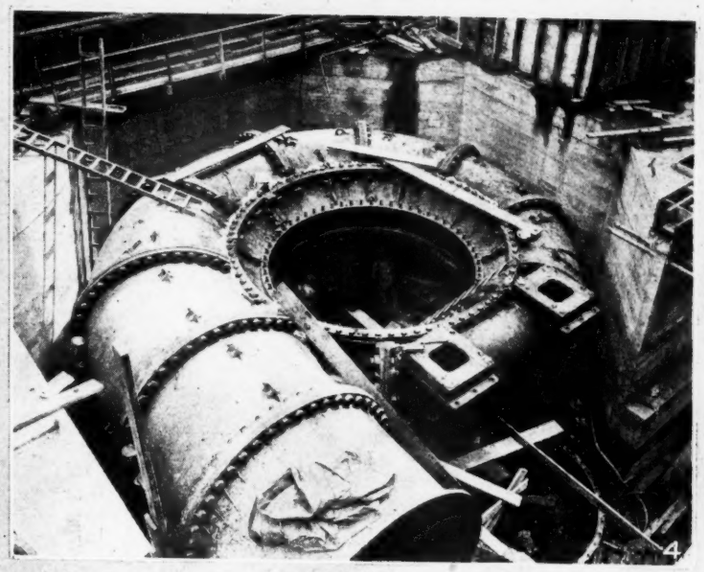
Fig. 6 shows that the screen house is located close to the edge of the cliff. Investigations of the magnitude of the surges showed that in case of sudden shutting down of the plant, the water level in the forebay might reach a maximum elevation of about 570. The bottom of the forebay is at elevation 514; therefore, this gives a possible maximum head at the intake to the penstock of 56 ft. On account of the poor quality of the rock between the screen house

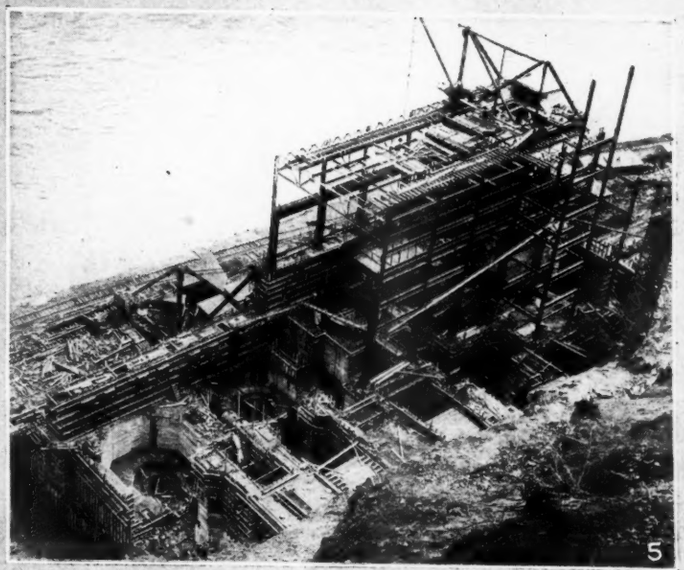
THIS is the third article on the Queenston-Chippawa development, Hydro-Electric Power Commission of Ontario, and describes the headworks, penstocks, power house and electrical equipment. The general features of the development were described in the June 27, and the turbines in the July 11 issues. The five main units in the present development are rated at 55,000 hp., and two of them have each carried a load of 64,000 hp. Each complete unit weighs approximately 2,000,000 lb., and the load on the thrust bearings is 1,000,000 lb. The headworks have been constructed for 9 penstocks. When the remaining 4 units are installed it is proposed to have them of a considerably larger capacity than the five now being put into service, so that the ultimate capacity of the plant will be about 600,000 hp.—the capacity provided for in the canal. On account of the large dimensions of the draft tubes and the great weight of the turbines and generators, parts of the building had to be designed to support loads of 7,600 lb. per sq.ft. The main penstocks are 450 ft. long by 16 ft. diameter at the top end and 14 ft. at the bottom end.











Figs. 1 and 4. Runner and casing of one of the 58,000-hp. turbines. This unit operates at 187.5 r.p.m. under a 305-ft. head, and since being put into operation has carried loads up to 64,000 horsepower.

Fig. 2. Looking into the turbine end of Johnson valve on main unit.

Fig. 3. Each of the penstocks is placed in a groove in the face of the cliff and covered with a minimum thickness of 24 in. of concrete.

Fig. 5. Queenston station under construction. The superstructure over the draft tubes is designed for a load of 7,600 pounds per square inch.

and the face of the cliff above the power house, and also having in mind the disastrous results that would follow a failure of the screen-house superstructure, which acts as a dam and forms the entrance to and control for the penstocks, this structure has been designed to stand the maximum head that may obtain in the forebay.

A section in plan through the entrance to one of the main penstocks, the service penstock and the ice chute, is shown in Fig. 7, from which it is seen that each main entrance consists of three openings. These are 12 ft. 8 in. wide by 29 ft. high at the rack supports, which are gradually reduced to a round opening 16 ft. in diameter at the point of connection to the penstock. Particular care was given to the design of the water passages to obtain smooth flow lines.

The piers between the penstock entrances are 6 ft. thick and are designed to stand full water pressure on either side, so that any one of the penstocks may be unwatered while the others are in operation. In the piers are provided steel-lined gate checks to support structural-steel gates. The racks are also held between these piers, and this was one of the reasons for dividing the entrance to each unit into three parts.

The racks are split horizontally in two sections, and consist of 3-in. by $\frac{3}{8}$-in. bars supported on edges on 5-in. centers; they are held rigidly in a structural steel frame. The bars and supporting structure of the racks are designed to resist a head of 10 ft. with a stress of 20,000 lb. per sq.in. in the steel.

Just in front of the entrance to the penstocks is a concrete curtain wall that extends down 12 ft. below normal water level, to prevent, as much as possible, floating ice and débris from reaching the racks. Provisions are made for directing this material into the ice chute. A trash trench in the bottom of the forebay immediately in front of the screen house is provided to collect any material that may float along the bottom of the forebay. Any débris or ice that may reach the racks is raked into a trough behind them and is washed into the ice chute. Only one penstock is provided for the two service units, this penstock dividing in the power house to supply the two turbines. The entrance to this penstock is a bell mouth, instead of taking the form of that for the main units. A clear width of 25 ft. is provided in the ice chute bay, with a Stoney type gate, that can be lowered to dispose of floating débris and ice, which is carried to the river below through a concrete pipe 10 ft. in diameter.

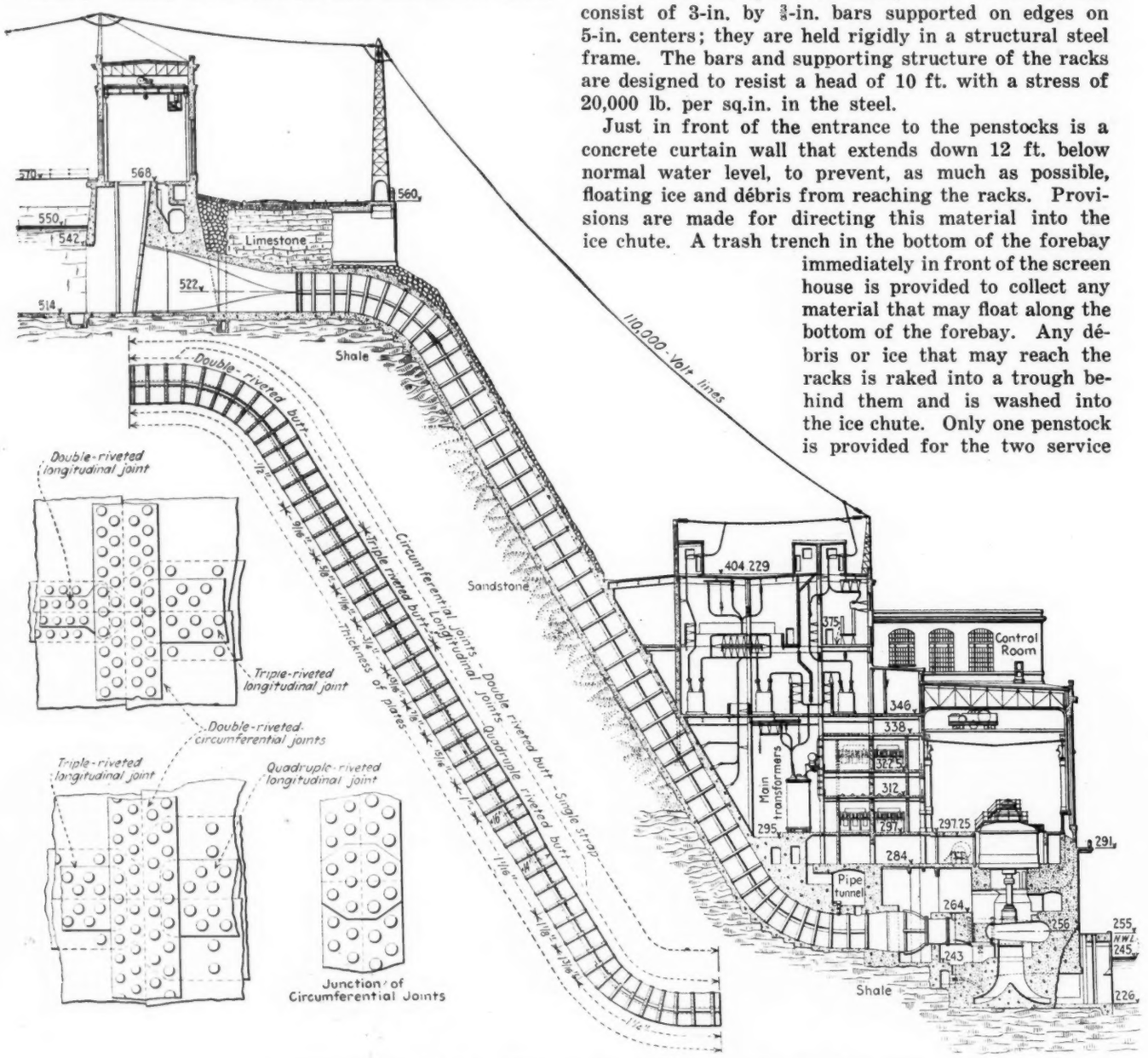


FIG. 6. SECTION THROUGH SCREEN HOUSE, PENSTOCK AND POWER HOUSE

On account of the poor quality of the rock at the top of the cliff the superstructure of the screen house has been designed to withstand the full head of water due to a surge in the forebay. The steel-plate penstocks are placed in grooves cut in the face of the cliff, and are covered with a minimum thickness of 24 in. of concrete. For 55 ft. above normal tail-water level no openings have been left in the station walls by which water from the river can enter.

Each of the main turbines connects to the forebay through a steelplate penstock 450 ft. long having a diameter of 16 ft. for about two-thirds of its length and 14 ft. for the remaining distance. Great care has been exercised in the design and construction of these penstocks to keep the losses at a minimum. Fig. 6 shows the excellent arrangement of the penstocks, there

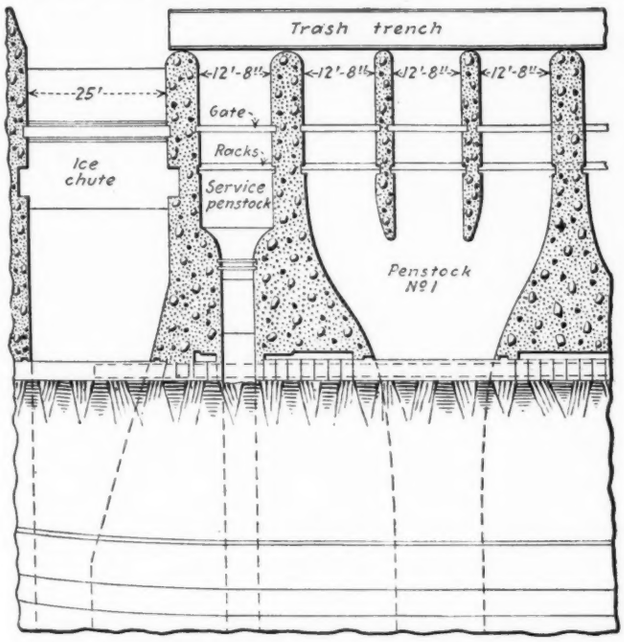


FIG. 7. PLAN VIEW OF ENTRANCE TO ONE MAIN PENSTOCK, SERVICE PENSTOCK AND ICE CHUTE

being but two bends, which are held in massive concrete anchor blocks.

Each section of the penstock is made up of two semicircular plates varying in thickness from $\frac{1}{2}$ in. for the top section to $1\frac{1}{4}$ in. for the bottom sections. All longitudinal joints are on the horizontal center line, are double-butt-strap riveted, varying from double-riveted at the top to quadruple-riveted at the bottom end. (See insert at left in Fig. 6). All circumferential seams are single-butt double-riveted, with the butt strap on the outside and electrically welded on the inside to make the joint water tight. With this type of joint the only obstruction to the flow of the water is the rivet heads. The longitudinal joints are calked on the inside to make them tight. For the lightest joints at the top end of the penstocks $\frac{7}{8}$-in. rivets are used, and $1\frac{3}{8}$-in. rivets for the heaviest joints at the bottom end. The efficiency of the longitudinal joints at the heaviest sections is about 85 per cent, with the general spacing of the rivets as shown in the insert, Fig. 6. The construction throughout has been such as to maintain the friction losses at a very low value. Each penstock lies in a groove cut in the face of the cliff, as indicated in Fig. 3, and is covered throughout its entire length with concrete of 24 in. minimum thickness.

The penstock for the service units is 5 ft. in diameter, and has been made up with lap joints, since friction losses here were not considered to be such an important factor as for the main units.

A Johnson valve, 14 ft. in diameter at the intake and 10-ft. diameter at the discharge end, connects the penstock to the turbine casing through a number of sections of cast-steel pipe. Fig. 9 shows one of these valves assembled in the shop. They are arranged for local control and also for remote control from the governor-control stand on the main operating floor.

Exclusive of the steel-plate housing at the upstream end, the complete valve weighs approximately 247,000 lb., and the plunger, or moving element, 52,600 lb. The force required to move the plunger is extremely small, as no sliding surfaces are subjected to a difference of hydraulic pressure and only the friction of the plunger moving in the internal cylinder must be overcome. To unseat the plunger and fill the wheel casing, a force of 540,000 lb. is available, and to complete the opening stroke the available force is 2,230,000 lb. To close the plunger in dead water, the available force is 461,000 lb., and this is greater in moving water. A force of 1,769,000 lb. is applied on the plunger to hold it against its seat. In spite of the enormous size of the valve and forces for operation, the operator has absolute control of the stroke at all times and may stop the plunger immediately at any intermediate point.

In the present installation, which will probably be completed by the end of this year, there will be five main units. The turbines for the first two are of 58,000-hp. capacity and were built by the Wellman-Seaver-Morgan Co., the other three, which are of 55,000-hp. capacity, being supplied by the William Cramp and Sons Ship and Engine Building Co. One of the first two units is equipped with a bent draft tube and the other with a Moody spreading draft tube, as are the other three. A detailed description of the Cramp machines appears in the July 11 issue, and a similar description of the first two machines will be published with the story of the tests being run on the machines. The runner and casing for unit No. 2 are shown in Figs. 1 and 4.

In many hydro-electric plants equipped with vertical units, it is necessary to dismantle the whole unit to remove the runner. In the Queenston plant this dif-

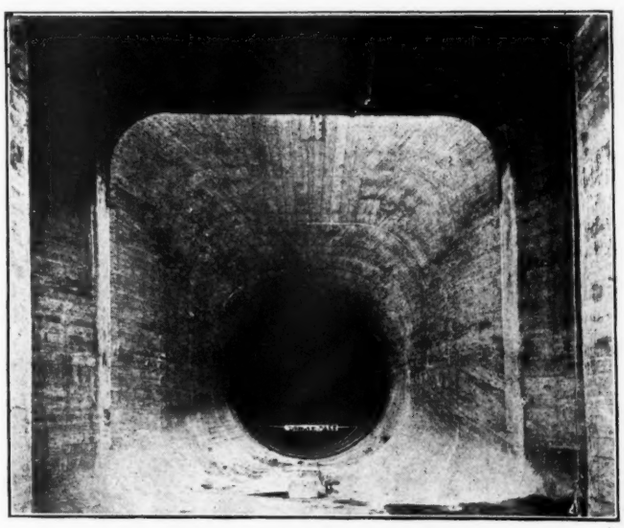


FIG. 8. ENTRANCE TO ONE OF THE MAIN PENSTOCKS

ficulty has been overcome by making the section of the draft tube immediately below the runner of cast iron and removable, so that the runner can be removed from below the casing. To facilitate this work, the turbine shafts, which are 30 in. in diameter, are made hollow by holes, 8 in. in diameter, through their centers. This makes it possible to utilize one of the power-house cranes in handling the runner. Using a hollow shaft also gives maximum strength with minimum weight.

A passageway running the full length of the power house has been provided so that when any runner is loaded onto a car it can be run to the south end of the plant and there handled by the power-house crane.

On each turbine the main bearing is about 6 ft. long and of the lignum-vitae type, lubricated with water from the penstock. Owing to the presence of considerable sand in the water at times, a pressure sand-filtering plant has been installed through which all the lubricating water is passed to prevent scoring of the turbine bearings. To insure good lubrication of the bearings, water is supplied to them at the top and middle points. As a precaution against stopping of the water to the bearings, a flow meter with indicator and alarm light are installed, which is intended to warn the operator when the bearings are not properly lubricated.

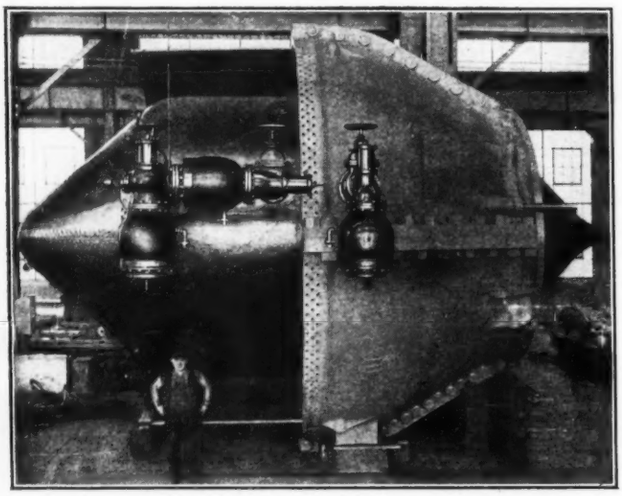


FIG. 9. ONE OF THE MAIN PENSTOCK VALVES
This valve is 14 ft. diameter on the penstock end and 10 ft. on the turbine end.

The governors on all five main turbines are of the I. P. Morris double floating lever type. The governor actuators and hand control are located on the main operating floor near the generator, where the main governor operating valves are located directly below the governor stand on a level with the turbine operating cylinders. The advantages of this arrangement are the short piping between the main valves and operating cylinders and the separation of the two main parts of the governor, giving free access for repairs.

The governor fluid used is filtered water containing about 1 per cent of soluble oil. This fluid is supplied to the governor at 150 to 200 lb. by a central pumping system. To guard against failure of the governor pumps, arrangements have been made to operate the governors on penstock pressure. This emergency supply has already been called into service with satisfactory results, since main units No. 1 and 2 have been put into operation.

At the south end of the power house are located the two service units, which are supplied by a 5-ft. penstock that divides within the power house into two branches and connects with two Johnson valves and then to the casings of the turbines. Each of these units is rated at 2,800 hp. at 500 r.p.m. under a 305-ft. head. These machines are of the vertical-shaft, single-runner type, and were built by the Allis-Chalmers Mfg. Co. The governors have their flyballs mounted directly on the turbine shaft. Oil is the fluid used and the governor system is entirely independent of that for the main units.

In the design of the power house the object has been to make each main unit and its bank of transformers a complete plant in so far as operation is concerned. The main units are set on 50-ft. centers, and if the power house was cut crosswise into 50-ft. sections, so that each contained a main unit, it would contain also the generator's oil switches, step-up transformers, all high-tension equipment for these transformers, and the outgoing end of the transmission line. In carrying out this scheme, it has been possible to transmit the power from the generator to the transmission lines in the shortest possible distance.

Reference to the cross section of the plant, Fig. 6, will show that around the main units there are four floor levels. At elevation 243 is the runner tunnel, through which the runners from the main units can be transported on a car if it ever becomes necessary to

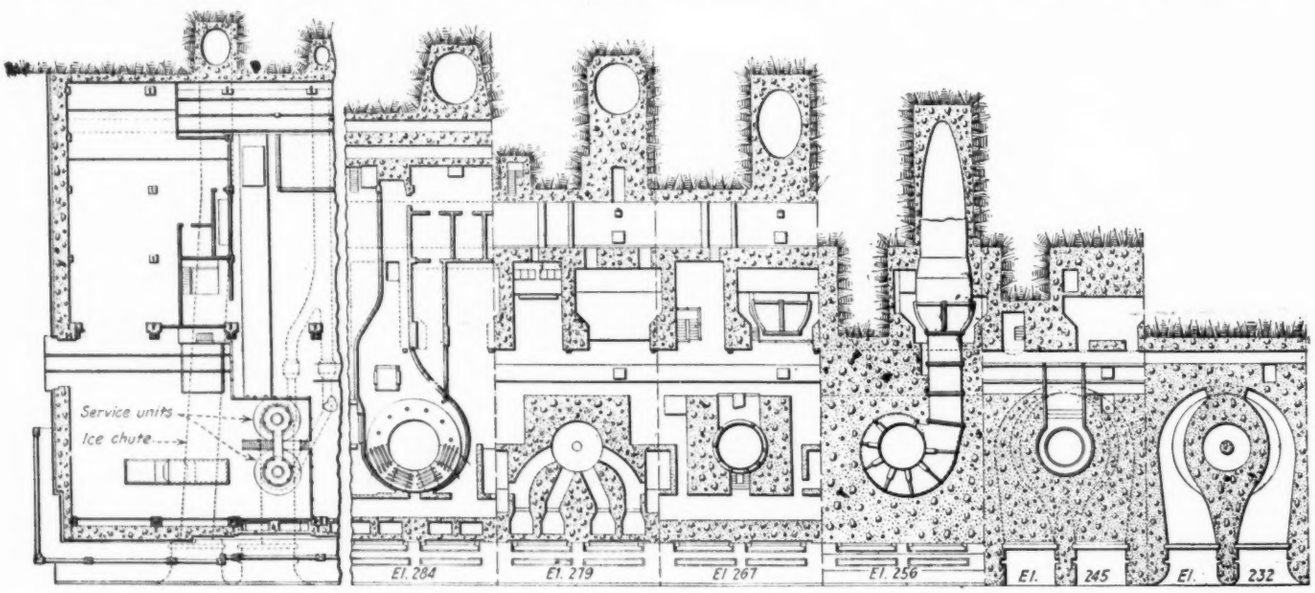


FIG. 10. PLAN VIEW AT DIFFERENT ELEVATIONS THROUGH THE POWER HOUSE

repair or replace them. Immediately below the runner tunnel is another small tunnel, which runs the full length of the plant. Into this tunnel all drainage in the plant is piped, and then flows to a sump at one end of the plant, where it is disposed of by two vertical-shaft pumps, the motors for which are located at elevation 284, so that the pumps may be operated in case of flooding of the lower levels of the station. At elevation 264 is the floor on which a large percentage of the

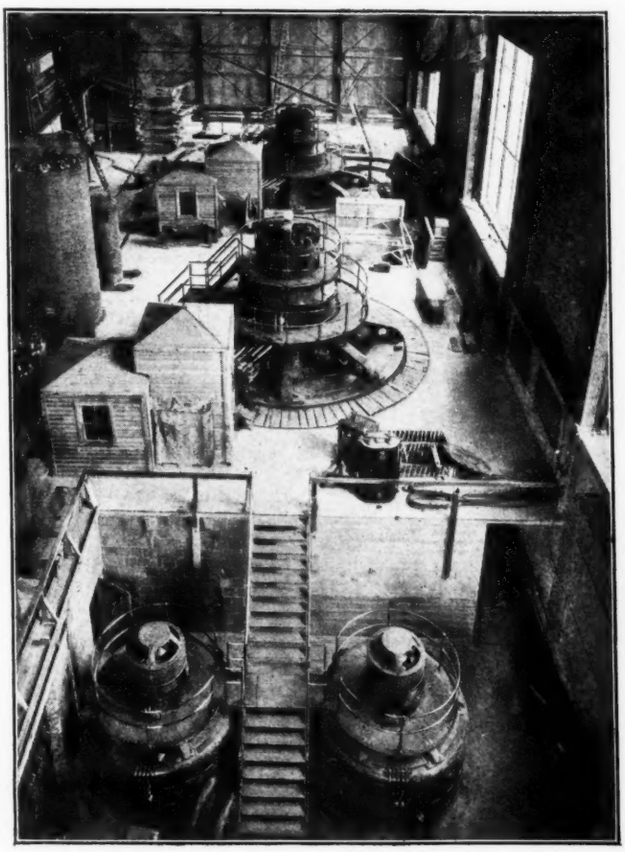


FIG. 11. INTERIOR OF PLANT DURING CONSTRUCTION
Two 2,800-hp. service units are shown in the foreground and two 45,000-kva. generators in the background. The operating floor comes level with the top of the generator stator frames.

auxiliary equipment is located. This floor is also provided with a track, so that equipment may be transported on a car to where it can be lifted to the repair floor on elevation 284 by one of the station cranes. This floor also serves to connect the space above each of the main units for convenient operation and inspection. The floor on the level with the base of the main generators is devoted chiefly to air passages leading to and away from the generators. The main operating floor is at elevation 297.25, being on a level with the top of the stators of the generators, only the upper part of the generators extends above this floor. The main transformers are also located on this floor. By comparing the construction at the various elevations in Fig. 10 with the elevation on Fig. 6, the general construction of the plant may be seen.

On the operating floor near each unit is a special operating stand, Fig. 12, designed by H. G. Acres, chief hydraulic engineer, Hydro-Electric Power Commission of Ontario. On account of the large capacity of these units, the importance of the operator knowing the conditions under which they are operating as well as having positive control at all times is apparent. A single operator from one position at this stand can observe the performance of the main unit and principal auxiliary equipment, and can also start the main unit, adjust the load, change over to hand control or shut down as required in regular operation, and, in case of emergency, close the Johnson valves, should the turbine gates become blocked, at the same time keeping in touch with the chief operator in the control room.

Ice jams in the Niagara River have caused the water to rise as much as 40 ft. above normal level. One of these caused the flooding of the Ontario Power Company's plant in 1909. Having this in mind, the Queenston plant has been designed so as to resist water up to 55 ft. above normal water level, and no openings that might permit the entrance of water are placed below this level.

The large size of the units and their great weight, about 2,000,000 lb., made very heavy reinforced construction necessary in many parts. The Moody draft tubes are 42 ft. in diameter at the bottom, a distance which it was necessary to span with a concrete slab. The loads assumed to come on this structure amounted to 7,600 lb. per sq.ft. This slab, which is 9 ft. thick,

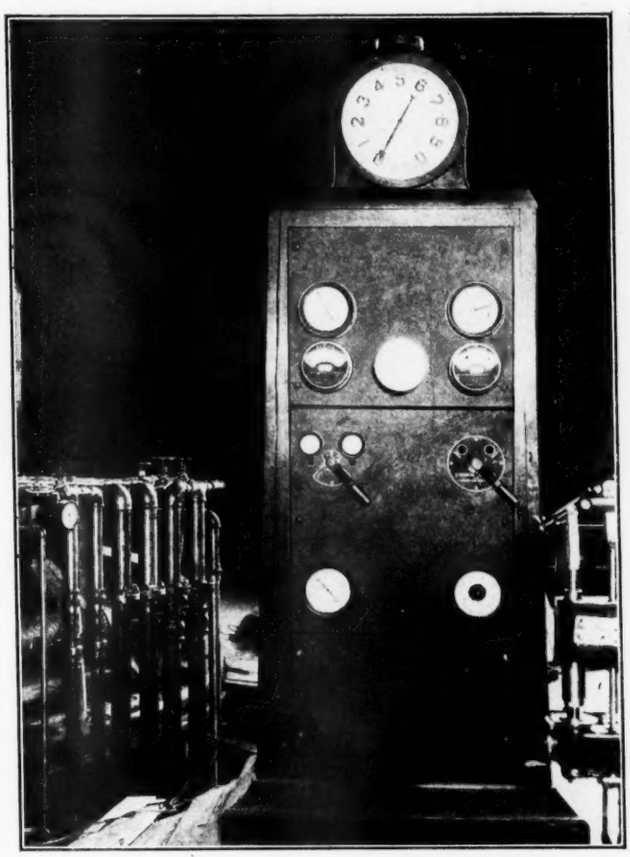
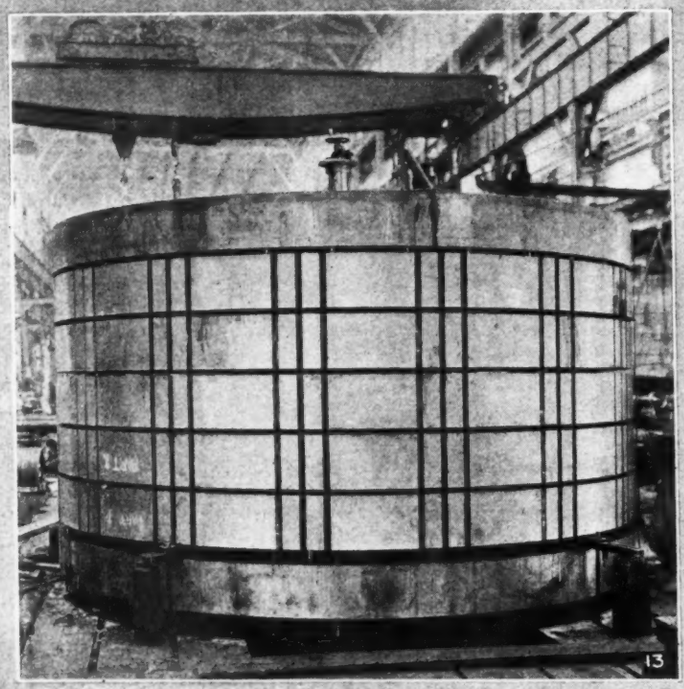


FIG. 12. ACRES CONTROL STAND FOR MAIN UNITS
This stand is located near the governor, and on it is mounted all the necessary equipment to show the operating condition of the main turbine and principal auxiliaries and also to give the operator complete control of the unit and Johnson valve.

was designed as a flat disk reinforced in four directions to clear the draft tube opening in the center. At the south end of the power house, on a level with the base of the main generator, is the erection floor, which is designed for a uniformly distributed load of 1,000 lb. per sq.ft. This floor provides space for assembling and



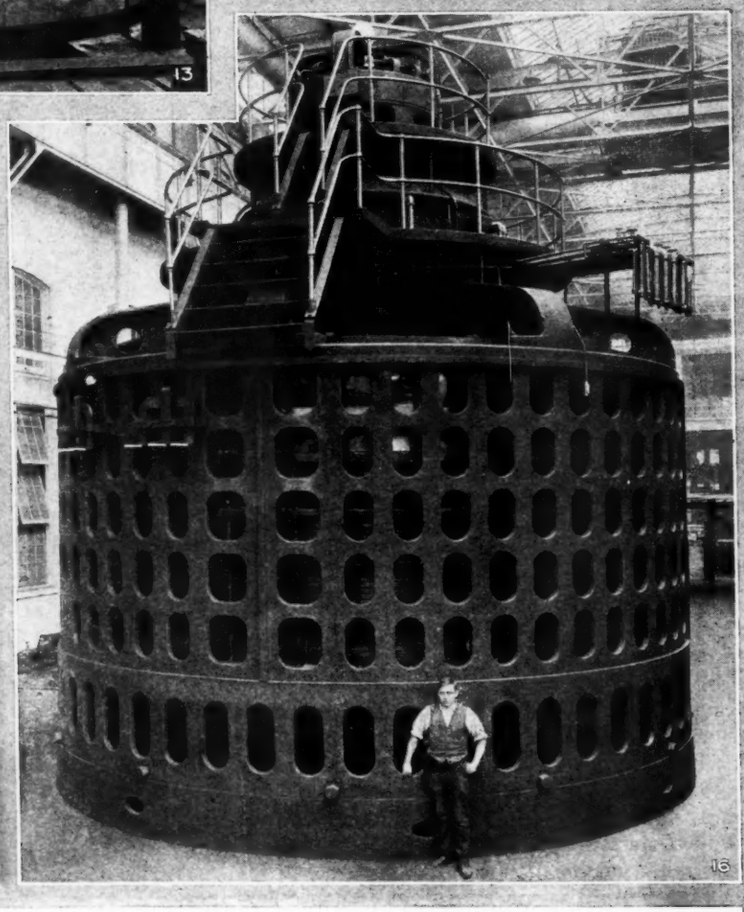


Fig. 13. Generator rotor spider to carry the polepieces, units Nos. 4 and 5. The rotor is made up of what may be considered 7 flywheels, the 5 center ones having dovetail grooves for attaching the polepieces. The two end wheels are added to increase the flywheel effect of the revolving element. The flywheel effect of the complete rotor is equivalent to 21,000,000 lb. at one-foot radius. The rotors for Nos. 1, 2 and 3 machines are cast-steel spiders on which a laminated steel rim is built to support the polepieces.

Fig. 14. One of the generator guide bearings. The shafts of the generators are of 30-in. diameter, with 8-in. holes through their centers.

Fig. 15. One of the stator coils shown in the foreground with a section of the stator core in the right background. To make one set of stator coils, 65 miles of wire was required, on which 450 miles of tape was wound for insulation.

Fig. 16. One of the main generators. Each machine weighs 1,400,000 lb., of which 615,000 lb. is in the rotor.

repairing large pieces of equipment. Openings are provided so that the runner tunnel can be reached with the crane to raise or lower runners or other equipment.

In the present development, the main electrical equipment consists of five 45,000-kva., 0.80-power-factor, 12,000-volt, 25-cycle, 3-phase vertical-shaft alternators, with direct-connected exciter operating at 187.5 r.p.m. and fifteen 15,000-kva. single-phase transformers.

Three of the generators and the fifteen transformers have been manufactured by the Westinghouse Electric and Mfg. Co., and two of the generators by the General Electric Co. These generators are capable of being operated continuously at 49,500 kva. with either voltage or current 10 per cent in excess of rated value. The over-all guaranteed efficiency of these generators is slightly above 97 per cent at 80 per cent power factor.

One of the generators complete weighs 1,400,000 lb., of which 625,000 lb. is in the rotor. The total weight of the rotating element plus the downward thrust of the water is slightly less than 1,000,000 lb. On three of the machines this weight is carried on a Kingsbury thrust bearing of 69-in. diameter located above the generators, where on the other two machines, General Electric Co. spring-type bearings are used. In addition to the thrust bearing, the generator has two guide bearings, one located in the upper bearing frame immediately below the thrust bearing and the other in the lower bearing bracket. On the lower bearing bracket are also located the air brakes for bringing the rotor to rest in case of emergency.

In three of the machines the guide-bearing housings are arranged for water cooling and babbitted bearings are used. In the other two machines the guide bearings are lubricated only, without water cooling.

Construction of Generator Rotors

The greatest difference in the construction of the two makes of generators is in the rotors. In the Westinghouse machines, the rotor consists of a cast-steel webbed spider on which a laminated steel rim is dovetailed. Each rim has dovetails on its inner periphery for holding it to the spider and has dovetail slots on its outer periphery for holding the polepieces, which are also of laminated steel. On account of the length of the rotor, three machine fits are used for the shaft and spider hub, and in addition the spider is keyed to the shaft. On the lower side of the outer periphery of the spider is mounted the brake ring, on which the air brake shoes rub to assist in bringing the rotor to rest in case of emergency.

In the two General Electric machines, the rotor consists of seven separate flywheels, shown in Fig. 13, the five center ones having dovetail slots on their outer periphery for holding the polepieces. The two end wheels are used only to give additional flywheel effect to the revolving mass and improve the speed regulation of the unit. The polepieces are built of ½-in. punchings, and are riveted together between heavy steel end-plates. Each polepiece is held to the rotor by three dovetails, designed so that at double normal speed the stress will not exceed 50 per cent of the elastic limit. At normal speed the flywheel effect of the complete rotor is about 21,500,000 WR^2. To provide for ample ventilation, the flywheel hubs have been made slightly wider than the rims, so that air may pass between the rims to the openings between the polepieces. Circulation of the air is also assisted by fan blades on the rotor ends.

In one of the machines, there are 65 miles of wire used in one set of stator coils, on which 450 miles of tape is used for insulation; the stator core is built of 110,000 punchings and one set of field coils required 3½ miles of strip copper.

Fig. 17 shows the general scheme of ventilation of one of the Westinghouse machines, which is practically the same for all five units. Cooling air is taken from the turbine operating floor up through the machine windings, and is discharged into a concrete duct, which

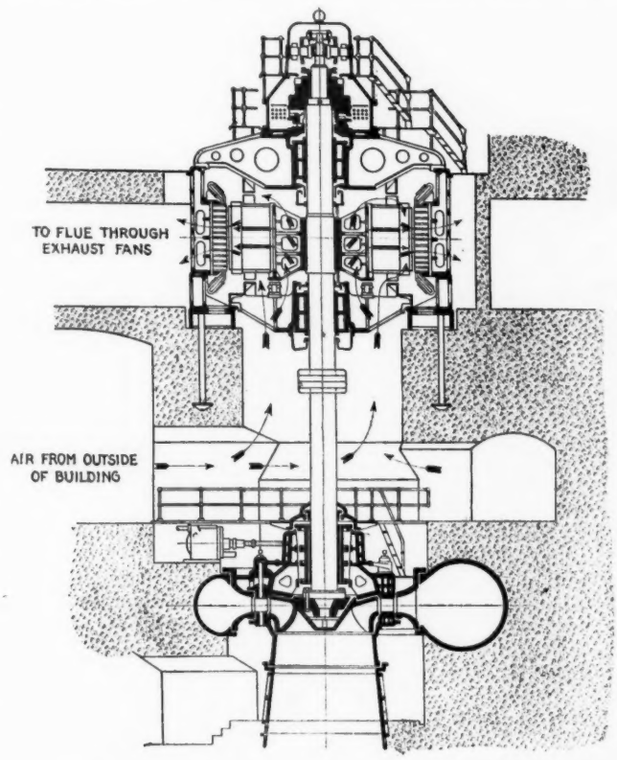


FIG. 17. SECTION THROUGH GENERATOR AND TURBINE, SHOWING CIRCULATION OF VENTILATING AIR

Over 4.5 tons of air per minute passes through one of the generators.

is enlarged at one end to accommodate the generator. In addition to the fan effect produced by the revolving element, an exhaust fan is located in the ventilating duct to assist in the passage of the air. Approximately 120,000 cu.ft. of free air per minute is required, and may be taken from outside the power house or from the generator room; it can be exhausted through a duct to the roof or to different parts of the plant for heating purposes. It is interesting to note that every 2½ hours each machine passes a weight of air equivalent to that of the generator; namely, 1,400,000 lb. It is expected that, when all five machines are in operation, by recirculating the ventilating air in the plant it will be sufficient to heat the plant at all times.

The main leads from the generators leave near the top of the machine and are carried to the switching equipment in the form of a bus construction. One of the features of the plant is extensive use of differential protection, which is not only applied to the generators but also to the power transformers. When the differential relays operate to trip a generator off the system, the field circuit is opened, the ventilating fan shut down and the damper in the air duct closed.

The chief source of excitation for the main generators is the 150-kw. 250-volt direct-connected exciter on

each main unit. This machine is of the shunt type, with commutating poles and especially designed for use with a voltage regulator. An auxiliary source of excitation is provided for by a motor-generator set, consisting of a 150-kw. shunt-interpole 250-volt direct-current generator driven by a 2,300-volt motor supplied from the service bus. This set is intended to excite any one main unit and to work with the voltage regulator of that unit.

Each 12,000-volt oil switch is located in a room by itself, as are also the disconnecting switches belonging to each oil switch. The tanks for the 12,000-volt circuit breakers are of 36-in. diameter, and have been tested to 500 lb. per sq.in. On the 110,000-volt breakers the tanks are 6 ft. in diameter and have been tested to 250 lb. per sq.in. The over-all height of these breakers is 14½ ft. and the length 25 ft.

All services except oil switch control and signal lamps are operated on 25-cycle current. Power is obtained

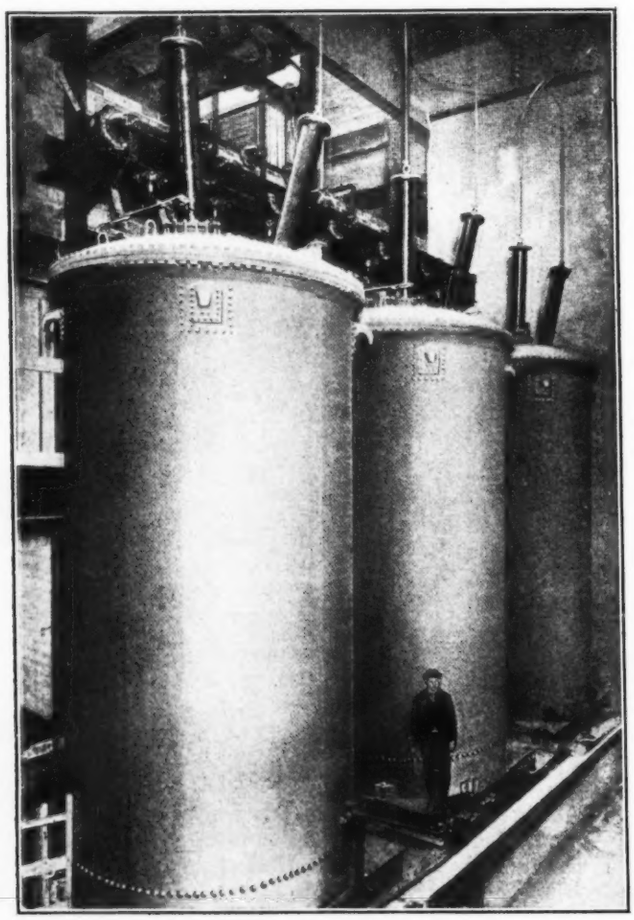


FIG. 18. ONE OF THE 45,000-KVA. BANKS OF TRANSFORMERS WHICH STEP THE VOLTAGE FROM 12,000 TO 110,000 VOLTS

from two service generators, each having a capacity of 2,200 kva. and generating 2,300-volt, 25-cycle currents. In addition, power for station service is available through a 12,000-volt line from the Ontario Power Co. plant. In general, all motors of 25-hp. capacity or larger are 2,300 volt, while smaller 3-phase motors operate on 550 volts.

As the station has been laid out, one generator, one bank of 12,000- to 110,000-volt transformers and 110,000-volt line constitute a unit having a normal capacity of 45,000 kva. As indicated in Fig. 19, arrangements have been made both on the 12,000- and 110,000-volt equipment for switching any line or generator to any bank of transformers.

The present power-house building for 5 units will be 350 ft. long, but the complete plant will ultimately be about 700 ft. long. It is planned to locate the control

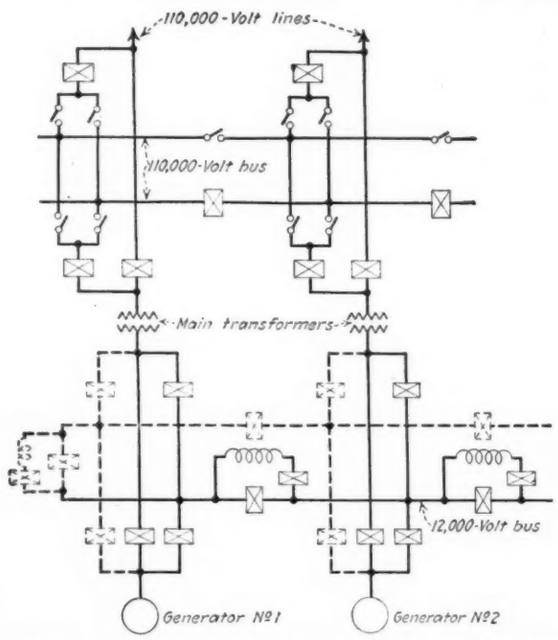


FIG. 19. WIRING DIAGRAM OF MAIN CONNECTION FOR TWO UNITS

room on the roof of the plant midway between the two ends. This room will be arranged in units also, so that bench, instrument, relay and recording boards for each power unit may be symmetrically arranged.

Physically, the fifteen step-up transformers are the largest single-phase units in operation. They are rated at 15,000 kva. output at 80 per cent power factor with 12,000 volts primary and 63,500 volts secondary. They are connected in banks of three, delta on the primary and star on the secondary, to give normally 110,000 volts, although taps are provided on the high-voltage side so that the line volts may be varied up to 122,000 volts. Each transformer is contained in a boiler-steel tank of 9 ft.-6 in. diameter, designed to withstand a pressure of 150 lb. per sq. in. or a 24-in. vacuum. The tanks are 21 ft. high and the total height of the transformers to the top of the high-voltage insulators is 28 ft. In the winding of each transformer there was used 11,000 lb. of copper, and the magnetic core contains 60,000 lb. of steel laminæ. Completely assembled transformer, tank, insulators and oil, one unit, weighs 205,000 lb. From 4,000- to 15,000-kva. load at 80 per cent power factor, the efficiency of these transformers is not less than about 98.5 per cent, and, at 9,000-kva. load, it reaches about 98.75 per cent. At 100 per power factor and 9,000-kva. load, the efficiency reaches 99 per cent. Arrangements have been made in the station so that any one of the transformers can be easily loaded on a car and then moved out where it can be handled with the main station cranes.

Power wishes to acknowledge the assistance and co-operation rendered the editor by the engineers of the commission and the manufacturing companies in the preparation of this article.

Refrigeration with Two Suction Pressures

Refrigerating engineers have long debated the merits of two-pressure compression. Professor Macintire shows by diagrams and examples the results to be expected. It is worth reading.

By H. J. MACINTIRE
Assistant Professor of Refrigeration, University of Illinois

IN MECHANICAL refrigeration it was necessary at first to give attention to the development of the compressor as to materials of construction and tightness, to the exclusion of stage compression, mechanically operated valves or compression at two or more pressures in the same cylinder. The compressor as now built has become a reliable, serviceable machine, and these refinements can well be given consideration. Each of these devices, which more or less complicate the system, should be carefully studied in order that the plant will justify itself, as regards both the first cost and the additional care during operation. Therefore, an attempt will be made to show where there will be an advantage in compressing the gas using two suction pressures in the same cylinder.

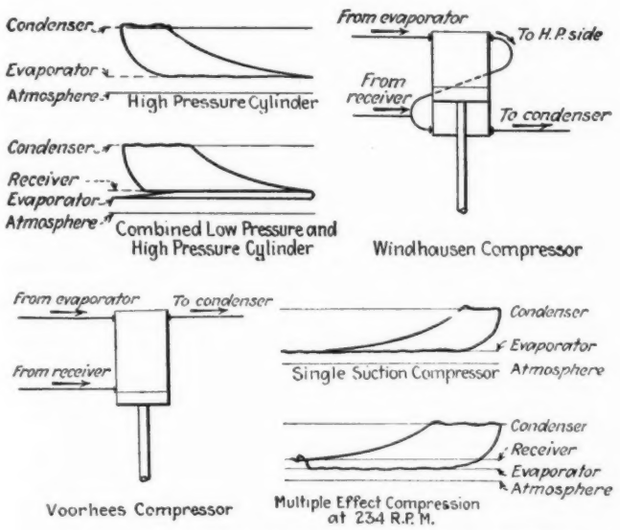


FIG. 1. TWO-PRESSURE COMPRESSION SYSTEMS

Why Have Two Suctions?

To begin with, Why have two suction pressures in the plant? It is understood by all engineers that refrigeration is obtained by boiling the refrigerant ammonia, carbon dioxide or other media in pipes or like containers, and that the boiling temperature depends on the pressure within the pipe. In order to perform useful refrigeration, the boiling refrigerant must take heat away from the substance to be cooled. But to get heat to flow from the brine, it is necessary to have a lower boiling temperature than that of the commodity being cooled, the boiling temperature of the refrigerant being at from 10 to 20 deg. F. below that of the commodity. Under these circumstances a steady boiling action is likely to take place with a rate of heat transfer of from 20 to 40 B.t.u. per square foot of surface per hour.

Should it be desirable to hold a lower temperature at one place than at another, so that temperatures of boiling — 10 deg. F. and + 20 deg. F. are required, it would be impossible to operate a simple machine under a single pressure of 30 lb. gage (corresponding to 20 deg. F. for ammonia), for the lowest coil temperature would be 20 deg. F., and consequently it would be impossible to obtain a temperature of — 10 deg. F., or in fact any temperature below 20 deg. F. Neither would it be desirable to operate at 8.5 lb. gage (corresponding to an ammonia boiling temperature of — 10 deg. F.), as under these conditions, although a lively boiling action will take place in the 20-deg. F. coils of about four times what was obtained before, this increased action being due to the increased temperature differences between the refrigerant and the room. The capacity of the compressor, as far as the capacity at the higher refrigerating temperature is concerned, would be reduced about 50 per cent, and the horsepower per ton required for the compressor would be increased about 58 per cent.

More Than Two Suctions Seldom Carried

It is highly desirable to operate the plant so as to get the highest economical suction pressure for the individual coils, but in practice it is seldom that more than two suction pressures are carried, and whether one or two are actually used depends on the amount of refrigeration used in each case. Examples in practice of the use of two pressures are in the case of ice-making, where the cans can be cooled under one system at 35 lb. gage with ammonia, and the brine in the brine cooler or the brine tank can be cooled at the second suction pressure of 20 or 22 lb. gage; in ice cream plants or where sharp freezers are required in addition to other refrigeration, the two-pressure system can be used.

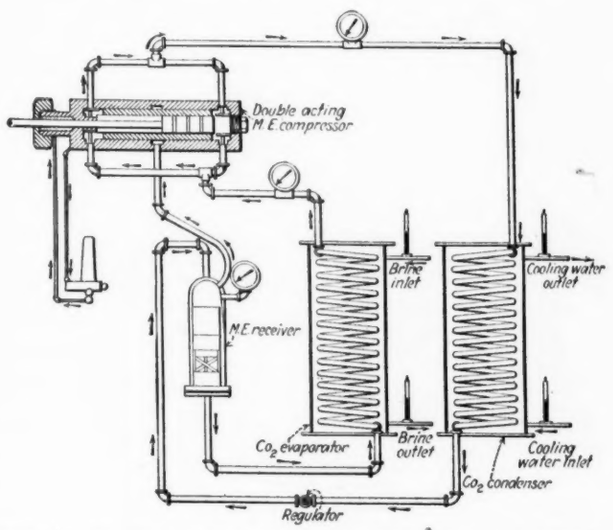


FIG. 2. CO_2 MULTIPLE-EFFECT REFRIGERATION SYSTEM

Having shown the need of two suction pressures, it

is now the proper occasion to explain how these pressures may be obtained. Of course it is possible to use a separate machine for each suction pressure, or to use the two cylinders of the duplex machine so that each will operate on different pressures. Or the two ends of a horizontal double-acting machine may be piped so that they will be working on different pressures. Each of these methods has the same principle—that of single-stage compression.

The Windhausen Method

The so-called Windhausen method, Fig. 1, is different in detail but fundamentally the same as those just mentioned. The low-pressure gas is compressed in one end of the cylinder to a pressure just sufficient to make it pass into the suction of the other end of the compressor, where it mixes with the high-pressure suction gas. This is similar to stage compression, but there is the possible objection that the discharged gas from the low-pressure cylinder may be insufficiently cooled before the discharge into the high-pressure cylinder. The second method, shown in Fig. 1, is that employed by the Apeldooen Company of Holland, the Seagers Company of England and the Carbondale Company of this country, and is usually spoken of as the multiple-effect compression system devised by Voorhees.

In this system, the ordinary compression stroke will draw in gas at the lower pressure until the end of the stroke, and then connection is made to the second suction line, holding the higher pressure, by the piston uncovering ports in the cylinder at or near the end of the suction stroke. Fig. 2 outlines a CO_2 system arranged in this way and multiple-effect ammonia compression is the same in principle. When the ports shown in the middle of the cylinder barrel are uncovered, the high-pressure gas flows into the cylinder, compressing the low-pressure gas already in the cylinder until the cylinder pressure approaches that of the receiver high-pressure line. In this way, one cylinder performs the function of two, and it would appear that considerable gain is obtained. There is a gain, but in many cases the advantage of using this so-called multiple-effect compression is not very great, whereas in other cases the advantage is decided.

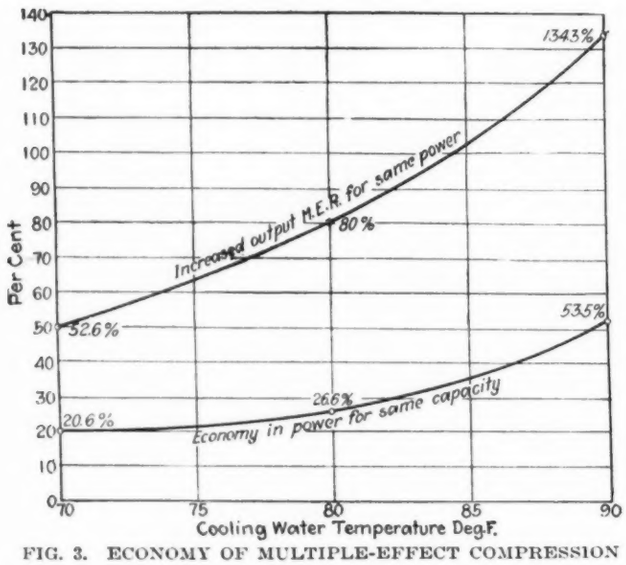


FIG. 3. ECONOMY OF MULTIPLE-EFFECT COMPRESSION

The chart in Fig. 3 gives some indication of the advantage of multiple-effect compression over the usual method in a CO_2 system. Indicator diagrams from a CO_2 machine operating with and without the multiple effect appear in Fig. 4. These show the gain in capacity.

As an example of the method of finding the saving effected by the use of multiple-effect compression in ammonia compression, assume the following conditions: Discharge pressure in the system, 185 lb. abs.; suction

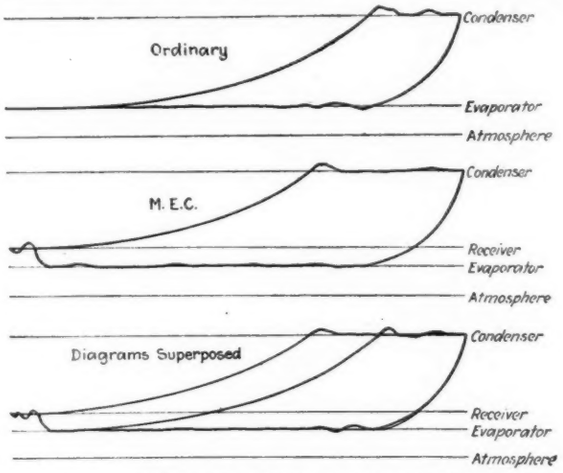


FIG. 4. DIAGRAMS FROM TWO-PRESSURE CO_2 COMPRESSOR

pressures, 30 and 45 lb. abs.; cylinder capacity, 10 cu. ft.; no clearance; adiabatic compression and expansion; both machines to be operated at the same speed. Theoretical indicator diagrams for these conditions are shown in Fig. 5.

The refrigerating effect equals the total heat in the ammonia vapor at the suction pressure (assuming a saturated condition) minus the heat of the liquid at the head pressure, or $R = H_2 - h_1$. In the problem, the total heat H_2 at 30-lb. suction pressure is 611.4 B.t.u., and h_1, the heat of the liquid at 185 lb., is 145.2 B.t.u. The refrigerating effect R becomes = 611.4 — 145.2 or 466.2 B.t.u. For a 45-lb. suction pressure, since the total heat at 45 lb. is 616.9, the refrigerating effect becomes 616.9 — 145.2 = 471.7 B.t.u.

The weight of ammonia in 10 cu. ft. at 30 lb. pressure is $10 \div 9.23 = 1.08$ lb., and at 45 lb. it is $10 \div 6.3 = 1.59$. The additional capacity at 45 lb. over operating at 30 lb. is the difference between the weight of ammonia handled, or $1.59 - 1.08 = .51$.

As both machines operate at the same speed and have identical piston developments the mean effective pressures may be used to compare the horsepower input. Without multiple-effect compression the machine gives $1.08 \times 466.2 = 503$. B.t.u. of refrigeration for 67.7 lb. mean effective pressure.

With multiple-effective compression this becomes $(1.08 \times 466.2) + (0.51 \times 471.7) = 743.5$ B.t.u. refrigeration for 90 lb. m.e.p.

The relative saving then works out as follows:

$$\frac{\text{m. e. comp.}}{\text{Regular}} = \frac{743.5}{503} \text{ B.t.u.} = 1.47 + \text{The power}$$

required for multiple-effect is $\frac{90.0}{67.7}$ or 1.33 that for regular compression. This shows a gain of 47 per cent in the capacity of the machine for only 33 per cent extra horsepower required theoretically. If two ma-

chines had been used at 30 and 45 lb. suction pressure instead of one, there would also be nearly twice as much friction.

From the example, which is what would be expected in any case that might be chosen, there is an opportunity of reducing friction and the weight of the machine. There is also a theoretical advantage of an increase in refrigerating capacity of 47 per cent at the same time that the horsepower increased 33 per cent. It should be remembered that this is a theoretical advantage which may be reduced by wiredrawing effect if the area uncovered by the piston, or the separate valve used to admit the high-pressure gas, is not large enough for the purpose at the speed at which the compressor is running.

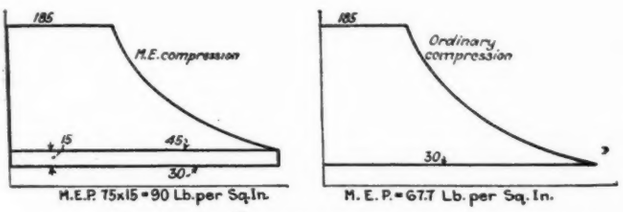


FIG. 5. THEORETICAL DIAGRAMS FOR AN AMMONIA COMPRESSOR

Another Lap-Seam Crack

BY R. L. HEMINGWAY,
Chief Boiler Inspector, California Industrial Accident Commission

The subject of the lap-seam crack has been written up and enlarged upon so many times that it would almost seem as if every child who has reached the fifth grade in school should know about the typical lap-seam crack, and yet we find, as in the instance recorded here, men past the prime of life who have worked with metal all their lives, who will stand by and watch a boiler under pressure actually tear itself open.

The foregoing prefaces the account of a lap-seam failure that recently occurred in California and which, contrary to the usual failure, proceeded to give ample warning of its intention to let go.

Referring to Fig. 1, it will be seen that a crack adjacent to the longitudinal lap seam is marked having an extent of 10½ in. Near the center of the crack is a chalk oval, which indicates a portion of the shell that had been welded. The boiler, an internally fired Scotch dry-back, was built in 1908. The shell is 54 in. in diameter by 6 ft. 6 in. long, and the plate is $\frac{7}{16}$ in. thick. The longitudinal lap joint is double-riveted, having $\frac{3}{4}$-in. rivets in $1\frac{3}{16}$-in. holes, pitched $2\frac{1}{16}$ in. apart, which gives an efficiency of 72.3 per cent. The shell contains seventy-nine 2-in. diameter tubes, 5 ft. long, which are expanded and beaded in $\frac{7}{16}$-in. heads. It also contains a plain cylindrical furnace 25 in. in diameter by 60 in. long, $\frac{3}{8}$ in. thick. The segment above the tubes is supported by seven $\frac{7}{8}$-in. through stays screwed through the heads with ends riveted over. In addition there is a dome 28 in. in diameter, which is double-riveted to the shell.

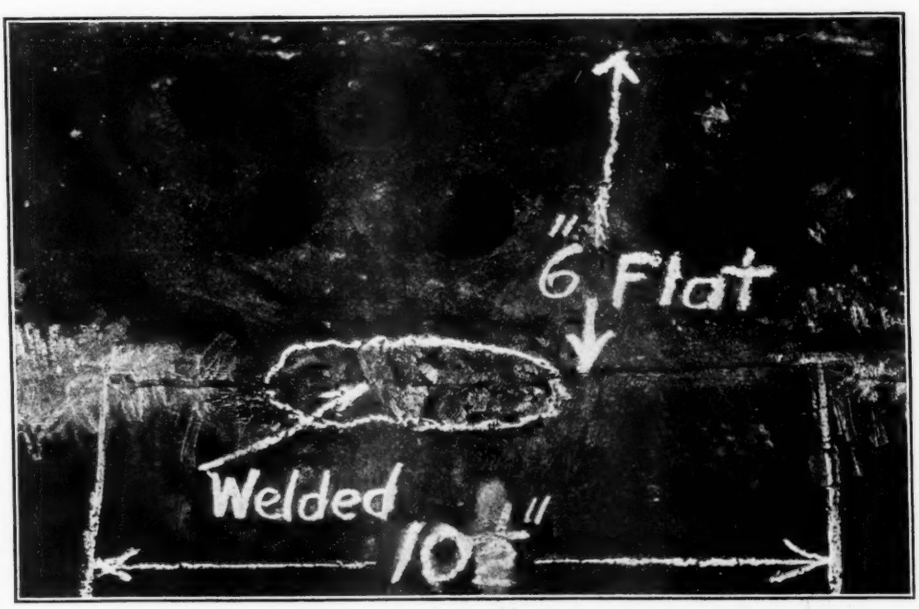


FIG. 1. EXTENT OF CRACK AND SECTION THAT WAS WELDED

Once more referring to Fig. 1, it will be noticed that there is a space marked "6 in. flat" running from the calking edge of the outer sheet of the lap to the point near the center of the longitudinal crack. This flat space is occasioned by the fact that, when the sheet was entered in the boiler-shop rolls, the space between the center of the top roll and the furthermost lower roll could not be curved unless the curvature were given by some other means before rolling actually began.

An article in the issue of *Power*, dated April 26, 1921, clearly illustrates this method of getting the curvature. In this case, however, this additional curvature was not provided, and as a consequence we find a flat spot approximately 6 in. in width, running the entire length of the boiler.

The record of inspections on this boiler, running from 1917, when regular inspections were first inaugurated in California under state supervision, shows that the boiler had been reported in good condition each year. There was not the slightest indication of there being anything wrong. Since this radical defect, however, did actually exist, it may be said to demonstrate the futility of such inspection. To controvert this, however, one can point out that where boilers are built to proper specification and design, adequate openings for inspection and cleaning are always required. The only openings found in this boiler were three hand holes—one in the front head each side of the furnace, and another in the front head above the tubes. This last was so located that owing to the position of the breeching it was impossible to obtain a view of more than a small portion of the inner surface, and this was in the steam space where no defects are usually anticipated.

The first evidence of anything being wrong occurred on a recent afternoon when under 85 lb. pressure a

slight leakage was observed coming from an opening about 1 in. long in the shell near the center of what is marked as the crack. The fires were drawn, the steam pressure allowed to drop, and the services of a local welder were requisitioned by the owners of the boiler to stop this leakage. The weld can be clearly seen in Fig. 1 and is approximately 4 in. in length. The following morning steam pressure was raised on the boiler and, when this had reached 60 lb., one of the owners who happened to be standing near the boiler noticed the recurrence of the leakage starting at each extremity of the weld. This leakage increased as the crack extended until, when it had reached a distance of 10½ in. over all, the owner thought it was time to draw the fire again and call for the opinion of a certified boiler inspector. Needless, to say, the inspector quickly recognized the nature of the defect and immediately ordered the boiler discontinued from service.

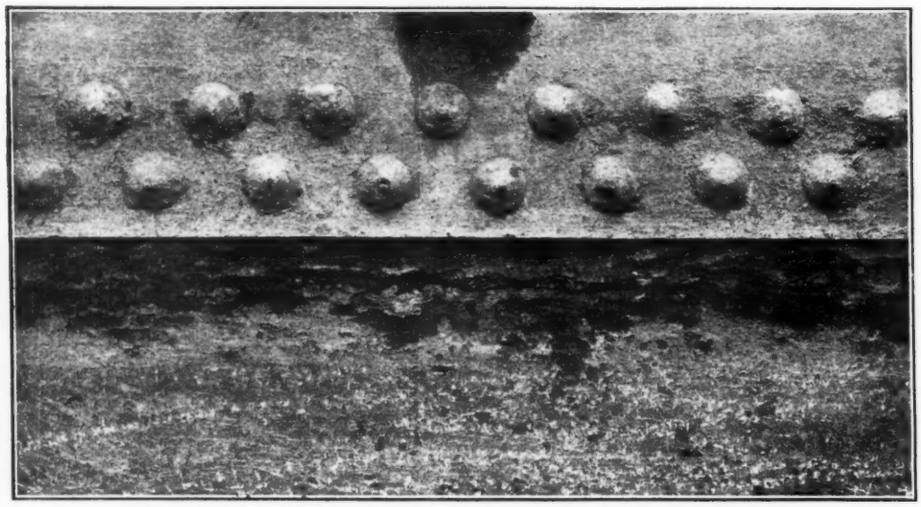


FIG. 2. WATER SIDE OF SHELL SHOWING CRACK AND DETERIORATION OF PLATE

Water Side of Shell Shows Deterioration

Fig. 2 shows the water side of this crack and demonstrates, more forcibly than anything the writer has ever before seen, the extent to which local destruction, through the deformity caused by the lap-seam, can be developed. Comparing the grooved section with the rest of the boiler plate, it was found that there is practically no deterioration, except at this one spot, and that the most dangerous one on the boiler. Examination of the rest of the boiler shell shows that the condition is uniform, the shell plates, heads and tubes all being in excellent condition, with the exception of the excessive grooving illustrated in Fig. 2, which extends the entire length of the boiler, but gradually decreases in severity as it approaches the head seams.

Fig. 2 shows exactly what one would expect, as of course the tendency of the boiler shell under pressure is to breathe more extensively at the points farthest from the staying effect that is produced by the head seams.

It is gratifying to note that the progress of the A. S. M. E. Boiler Code throughout the Union will gradually eliminate this type of construction in boilers over 36 in. in diameter, but in the meantime the tens of thousands of lap-seam boilers that are still operating in the United States constitute a menace to the lives of employees and to the property of boiler owners who, in spite of the publicity that technical magazines and textbooks have given this reprehensible type of construction, still continue to operate under pressures that are far in excess of that which common prudence would dictate.

Frequently, when an attempt is made to regulate the pressures on these old boilers, under the accident-prevention movement which has spread so widely through the country in the past ten years, it has been found that the moneyed interests have striven with all the influence of wealth at their disposal to prevent even the slow and gradual elimination of this type of boiler. As a consequence, the lap-seam boiler for many years to come will continue to take its toll of human life and to destroy thousands of dollars' worth of property, unless the individual states awaken to the terrific hazard that exists and profit by the experience of others, as did the State of Massachusetts when a lap-seam boiler blew up in the plant of the Grover Shoe Co., Brockton, Mass., killing 58 innocent people and injuring 117, in addition to doing property damage to the extent of a quarter of a million dollars.[1]

Laws Exist Pertaining to Other Hazards

The whole country has laws, state or municipal, regulating theaters in regard to fire exits and fireproof curtains, stage properties, etc., because hundreds of lives were lost in the Iroquois Theater holocaust in Chicago. The "Slocum" disaster in New York taught that overcrowding excursion boats means excessive life loss through panics, and almost universally laws now regulate the transportation companies. Even elevators and the humble mine skip may not carry more than a certain reasonable load, depending on size and cable capacity. Why, then, should not the dangerous lap seam also be reasonably regulated when the entire engineering profession is unanimous in its condemnation by reason of its undeniable potential catastrophe hazard?

The 1922 Report of the Society for Electrical Development shows that in 314 communities in this country, having an aggregate population of about 25,000,000 persons a total of 121,999 fires occurred during the year. Of this number 2,971, in residences and commercial buildings, could probably be attributed to the use of electric service, which gives 40.8 fires due to non-electrical causes for each fire of electrical origin. The electrical-fire ratio for the total is 2.43, but in 63 per cent of the communities it was less than this and in over 50 per cent of the places was not over 1.4. In 40 per cent of the communities it was less than 1 and in 30 per cent not over 0.5.

[1]This explosion was described in *Power*, May, 1905.

Protecting Alternating-Current Motors

By B. W. JONES
Engineer, Industrial Control Department, General Electric Company

The problem of properly protecting alternating-current motors against open phase, reverse phase and overloads is outlined and equipment to give this protection described.

MULTI-PHASE induction and synchronous motors are the most substantially constructed and apparently the least liable to trouble of all the electric motors, but the history of their service shows that they need protection against three conditions:

A. From overload current, which may result from too heavy a mechanical load on the motor, from abnormal frequency, or from abnormal voltage on the power lines;

B. From single-phase power, which may exist when attempting to start the motor or after the motor has started;

C. From phase reversal, which will cause the motor to rotate in an opposite direction to that intended.

Alternating-current motors are extensively used; however, the *A* and *B* conditions have not heretofore been properly protected against. Overload relays have

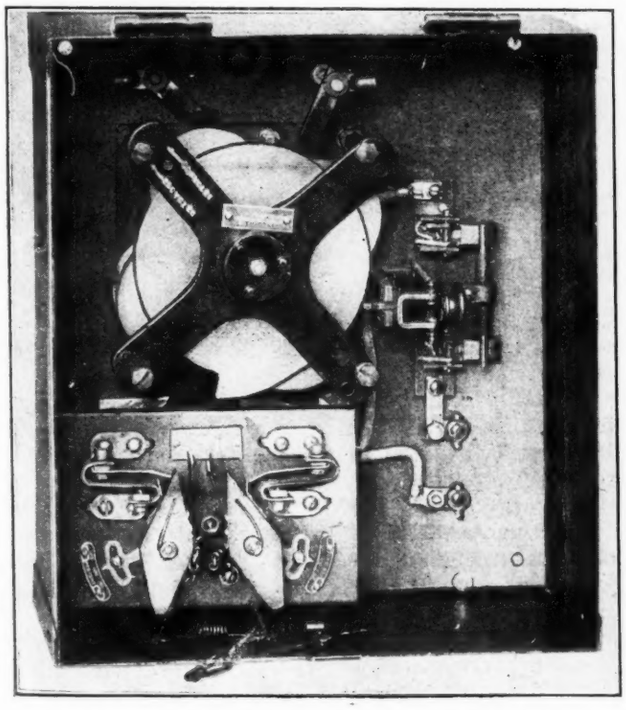


FIG. 1. PHASE-REVERSAL, OPEN-PHASE AND TEMPERATURE-OVERLOAD RELAY

been relied upon to a large extent to protect the motor against these two conditions but it is generally conceded that they have fallen short of expectations. The reason for most failures has been that the relays have interfered with production by tripping out too frequently and thus causing the operators to set them up, when they would cease giving trouble.

Recently two devices have been developed which jointly will protect against all three of these conditions;

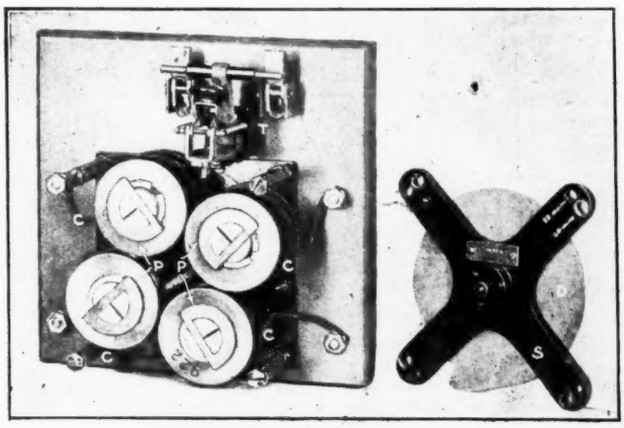


FIG. 2. PHASE-REVERSAL AND OPEN-PHASE RELAY WITH STEEL YOKE AND COPPER DISH REMOVED

these two devices have been mounted together as shown in Fig. 1 to be used for protecting multi-phase alternating-current motors. The device in the top of the box is an open-phase and phase-reversal relay, and the one at the bottom is a temperature-overload relay. Each device has a control contact which remains closed at all times except when it opens as a result of the condition against which it is protecting. These are reset by hand. The upper relay protects against phase failure, open-phase and phase reversal. The lower relay protects against a sustained overload, which would overheat the motor.

In Figs. 1 and 2 the construction of the open-phase, phase-failure and phase-reversal relay is shown. This relay has two independent torques. One torque is produced by the current flowing through each coil *C*, Fig. 2, independent of its relation to the other coils. The other torque is produced by the rotating field caused by the multi-phase action. That is, the north and south poles rotate around the four poles 1,800 times per minute when 60-cycle power is applied.

Single-phase induction relays have been built for years, and also multi-phase induction relays. The single-phase relay produces its rotation by a split-phase action in each magnetic pole by means of a pole shader, and the multi-phase relay produces its rotation by rotation from pole to pole, as in any induction motor.

By making a combination of a single-phase and a multi-phase relay and so connecting it that the two rotations oppose each other, we have the basis of an open-phase, phase-failure and phase-reversal relay. If the multi-phase action predominates, the rotating member comes up against a stop, and when power is removed it will remain there. If series coils are used and one phase to the motor opens, then phase rotation ceases but single-phase power continues and produces the

single-phase rotation of the relay in the opposite direction, causing a latch to be tripped.

Referring to Fig. 2, the foregoing features will be observed. The relay has four poles and four series coils *C*, which are connected as shown in Fig. 3. Each pole has a pole-shader *P*, and is so placed as to produce a torque in the copper disc *D* in a counter-clockwise

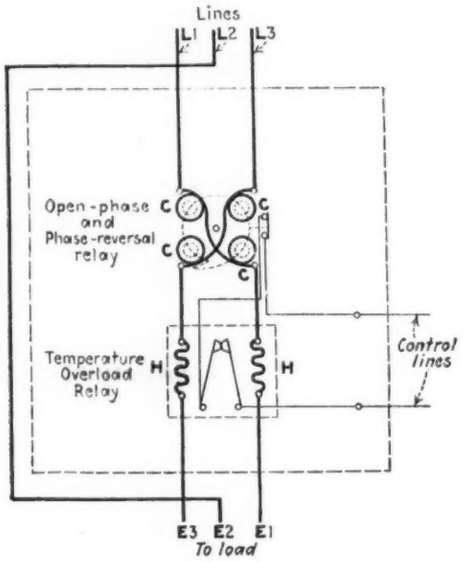


FIG. 3. WIRING DIAGRAM FOR FIG. 1

direction. The steel cross *S* also acts as a pole-shader to give a torque in the same direction as each shaded polepiece, and the two develop quite a respectable torque. With single-phase power these two forces cause the disc to rotate counter-clockwise and trip the contact *T*, which is a toggle arrangement.

When multi-phase power is applied the single torque remains, but there is added a torque produced by the rotating field, and this can be in either direction, de-

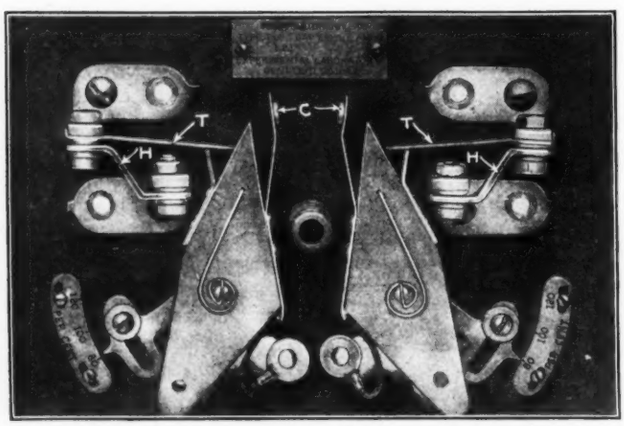


FIG. 4. TEMPERATURE-OVERLOAD RELAY

pending upon the connection. For normal operation these two torques should oppose each other, with the rotating torque predominating. This will bring the copper disc against a stop and produce no result. Therefore nothing happens when multi-phase power is applied or removed, but should any phase open, then only single-phase power remains and the reverse single-phase torque immediately trips the relay. The relay requires about 60 per cent of its continuous coil rating to trip. This means that if the motor, when running with an open-phase, requires less than 60 per cent of its rated current, the relay will not trip; but few loads will allow the motor to draw less than 60 per cent current with single-phase power, and if so, no harm can result. If phase-reversal occurs the relay will trip, since the multi-phase torque will be reversed.

Referring to Fig. 4, the construction of the temperature-overload relay will be seen. It consists of two duplicate units, insulated from each other. Each unit consists of a thermostatic strip *T*, a heater *H* and a control contact *C*. The thermostatic strip acts as a latch for the control contact and keeps it in contact with the corresponding one on the other half. When the heater heats the thermostatic strip above a specified value, the strip bends sufficiently to unlatch the control contact, and allows it to move away from the other

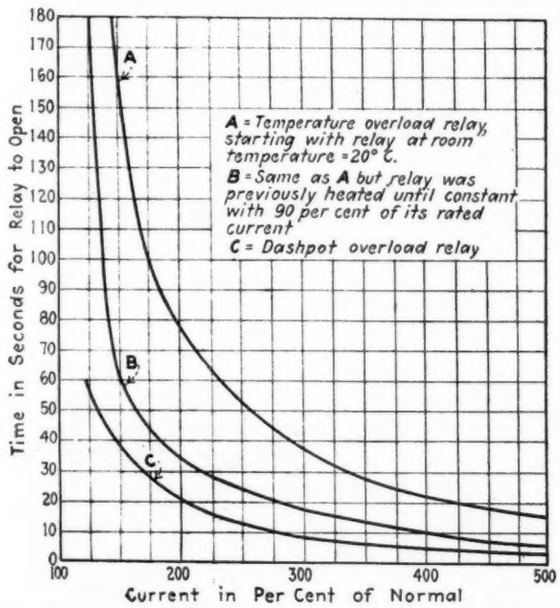


FIG. 5. TIME-CURRENT CURVES OF TEMPERATURE-OVERLOAD RELAY AND DASH-POT TYPE OVERLOAD RELAY

control contact, which results in opening the control circuit.

Below the heater is a calibrating arm which changes the position of the latch so as to permit it to trip at a different deflection of the thermostat. In its maximum position it requires 120 per cent current, and in its minimum position 80 per cent current to trip.

The time required to trip this relay with different currents through the heater is shown in Fig. 5. This current-time curve shows that more time is required to trip this relay with a certain overload than is required to trip an ordinary dash-pot magnetically operated overload relay. Therefore, the temperature-overload relay can be set so that a small sustained overload will finally trip it and yet will not be tripping on overloads of short duration which the motor is capable of standing. This will give the operator no occasion to set the relay up. However, the relay heater is generally selected so that the current rating of the motor will call for a setting of the calibrating arm in its approximate mid-position, which will thus allow the maximum at which the operator can possibly set the relay of only twenty per cent above the motor rating.

Finding the Comparative Efficiencies of Steam Engines

THE fact that one engine uses 18 lb. of steam while a second requires 24 lb. is not proof that the first engine is the superior. This article shows how a fair comparison can be made and explains the use of the total heat chart.

WE SPEAK of the mechanical efficiency of an engine, and in saying that this is 90 per cent, we indicate that of the power developed in the cylinder, 90 per cent is delivered to the belt as useful work. In like manner the heat converted into work in the engine cylinder compared to the total heat added to the medium (steam, air, etc.) is called the thermal

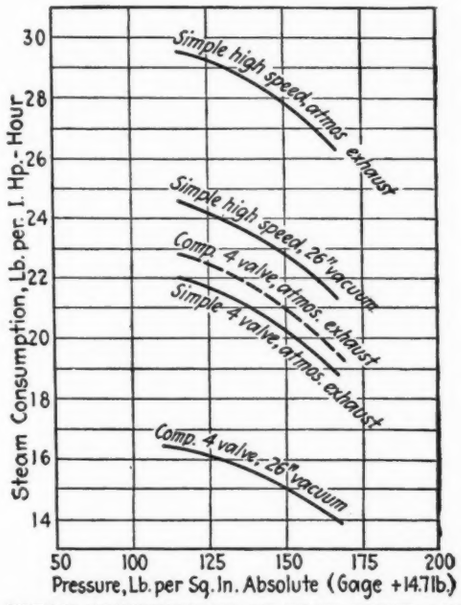

Steam Consumption, Lb. per I. Hp.-Hour
Pressure, Lb. per Sq. In. Absolute (Gage +14.7 lb.)
Simple high speed, atmos. exhaust
Simple high speed, 26" vacuum
Comp. 4 valve, atmos. exhaust
Simple 4 valve, atmos. exhaust
Comp. 4 valve, 26" vacuum

FIG. 1. STEAM CONSUMPTION OF HIGH SPEED AND FOUR-VALVE ENGINES, SIMPLE AND COMPOUND

efficiency of the engine. As example, if a steam engine consumes 18 lb. of steam at 150 lb. absolute per square inch for each indicated horsepower with the back pressure of 28 in. vacuum, the thermal efficiency may be found as follows: The heat contained in a pound of steam at 150 pressure is found by the steam tables to be 1,193.4 B.t.u. It is assumed that the condensate is used as boiler feed for it is not the engine's fault if it is not. Each pound of water leaving the condenser at 26 in. vacuum (1.9 lb. absolute) and 125 deg. F after being condensed from steam, contains 92.9 B.t.u. The heat to be added to bring the steam up to 150 lb. pressure, where it contains 1,193.4 B.t.u. is 1,193.4 — 92.9 = 1,100.5 B.t.u. If 18 lb. of steam are used per horsepower, the total heat added is 18 × 1,100.5 = 19,809 B.t.u. One horsepower-hour is the equivalent of 33,000 × 60 = 1,980,000 ft-lb. As one B.t.u. is equal to 778 ft.-lb., one horsepower is equivalent to 1,980,000 ÷ 778 = 2,545 B.t.u. We have used 18 lb. of steam to which was added 19,809 B.t.u. to develop one horsepower-hour. Our thermal efficiency is $\frac{2,545}{19,809} = 12.8$ per cent.

If the boiler pressure had been 100 lb. abs. per sq.in., the total heat in a pound of steam would have been 1,186.3 B.t.u., and if the engine operated with a back pressure of 14.7 lb. (atmospheric exhaust), assuming the feed water to go to the boiler at 212 deg., the feed water would contain 180 B.t.u. at 212 deg. The heat added to each pound would be 1,186.3 — 180 = 1,006.3 B.t.u. If the water rate of the engine under these conditions were 24 lb., the total heat added would be 24 × 1,006.3 = 24,151 B.t.u. The thermal efficiency would be $\frac{2,545}{24,151} = 10.5$ per cent.

It would appear from these figures that the first engine having a thermal efficiency of 12.8 per cent was superior in converting heat into work to the second engine which under other conditions of initial and back pressure showed only 10.5 per cent. However, this conclusion might work an injustice on the second

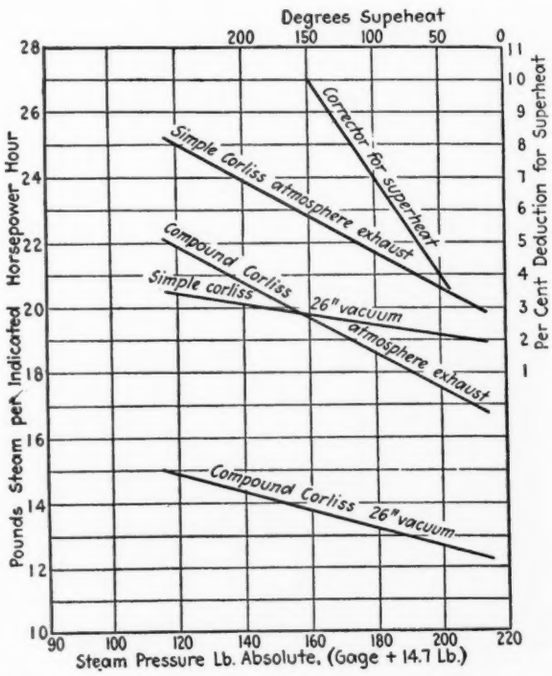


FIG. 2. STEAM CONSUMPTION OF CORLISS ENGINES

engine. In comparing the thermal efficiency we must keep in mind the conditions under which the engine operates. In other words, we should compare the results with those possible in a perfect engine operating under the same conditions of temperature and pressure. This is more easily understood in the case of a hydraulic system. Assume we have a waterfall of 100 ft. passing 330 lb. of water per minute. Now it does not matter whether this fall in the Rocky Mountains at

5,000 ft. above sea level or at sea level; all we can get out of the plant with no loss is 330 × 100 = 33,000 ft.-lb. per minute. If our waterwheel gave 29,700 ft.-lb. of work at the shaft, the efficiency of the wheel would be 29,700 ÷ 33,000 = 90 per cent. Now if it were possible to move the wheel down another 100 ft., giving a 200-ft. head, the maximum power a perfect turbine could develop would be 66,000 ft.-lb. If we had a wheel that developed 52,800 ft.-lb. under these conditions, while the output is greater than in the first case the efficiency is less, being only 80 per cent.

It will be seen that a mere statement of the amount of heat an engine uses per horsepower is of little value in determining how efficient it is in converting the available heat into work. For this reason the thermal efficiency tells us little. What is needed is a means of comparison of the performance of the actual engine with the results to be obtained from a perfect engine operating under the same conditions of mutual and final pressures. As has been shown in previous articles on the indicator, the Rankine cycle is used as the standard of comparison. It is possible by making the proper computations or by measuring the *T-N* diagram area, to find both the thermal efficiency of the perfect engine, this being called the Rankine cycle efficiency, and the efficiency of the actual engine compared to the efficiency of the Rankine cycle. This latter ratio is termed the efficiency ratio, or, better still, the Rankine efficiency of the actual engine. These steps consume some time and are seldom used since the Total Heat Chart is simpler. This chart, Fig. 3, is based on the *T-N* diagram, but the total heat instead of being represented by an area as in the *T-N* chart, is here made proportional to the ordinate while the entropy is read on the abscissa. The diagonal lines marked 75-80-90 are lines of quality showing the percentage of the water-steam substance that is dry steam. By their intersections with the pressure lines from lower left to upper right, the

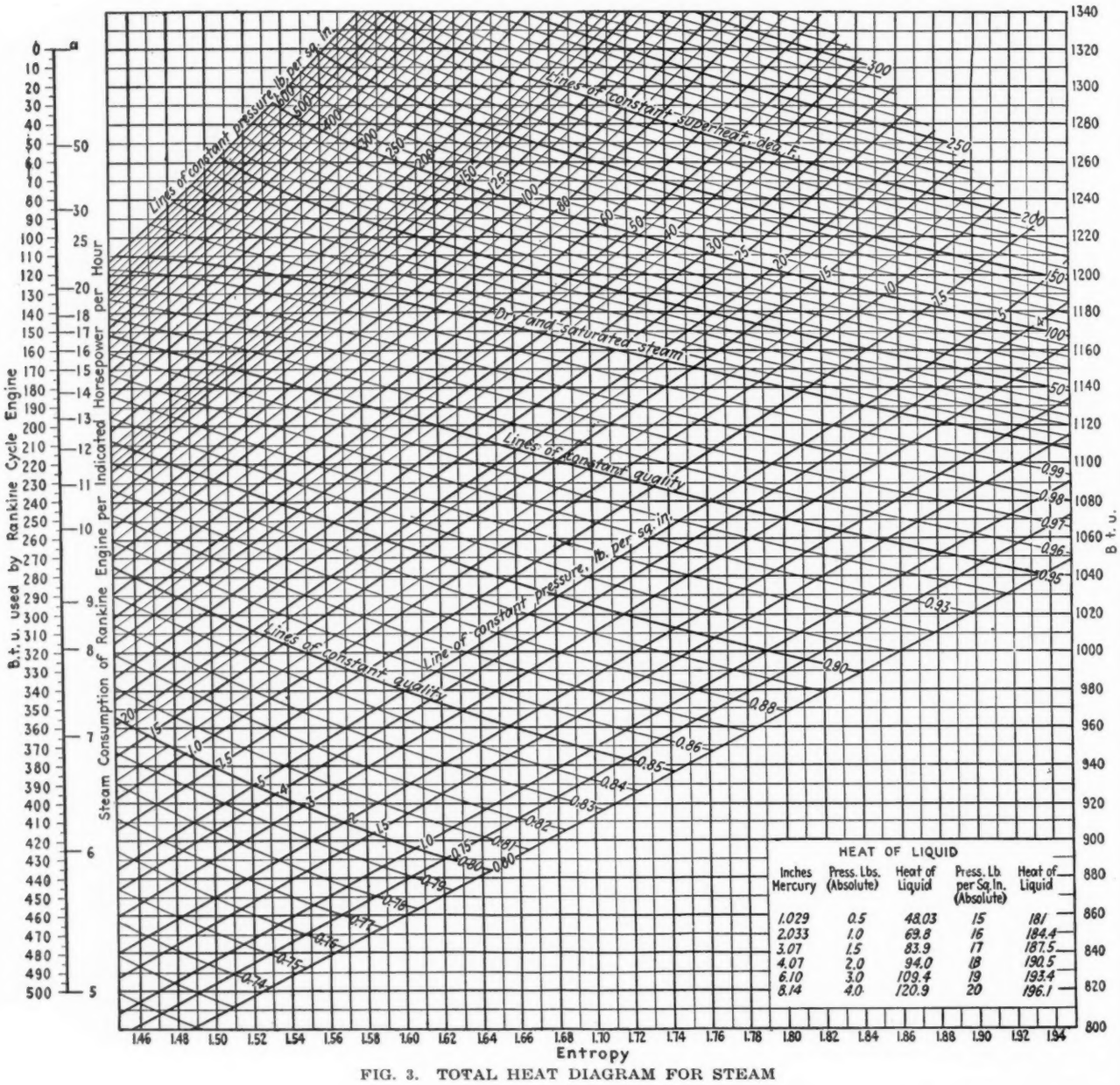

B.t.u. used by Rankine Cycle Engine
Steam Consumption of Rankine Engine per Indicated Horsepower per Hour
B.t.u.
Entropy
Lines of constant pressure, lb. per sq. in.
Lines of constant superheat, deg. F.
Dry and saturated steam
Lines of constant quality
Line of constant pressure, lb. per sq. in.
Lines of constant quality
HEAT OF LIQUID
Inches Mercury | Press. Lbs. (Absolute) | Heat of Liquid | Press. Lb. per Sq. In. (Absolute) | Heat of Liquid
1.029 | 0.5 | 48.03 | 15 | 181
2.033 | 1.0 | 69.8 | 16 | 184.4
3.07 | 1.5 | 83.9 | 17 | 187.5
4.07 | 2.0 | 94.0 | 18 | 190.5
6.10 | 3.0 | 109.4 | 19 | 193.4
8.14 | 4.0 | 120.9 | 20 | 196.1

FIG. 3. TOTAL HEAT DIAGRAM FOR STEAM

total heat in a pound of a mixture of steam and water of any qualities may be used from the heat scale at the right in B.t.u. The intersection of one of the pressure lines, say the one marked 100 lb., with the dry saturation line allows one to read at the side the total heat in one pound of dry steam at this pressure, or 1,186 B.t.u. The lines above the saturation line marked "constant superheat" show the increase in steam tempera-

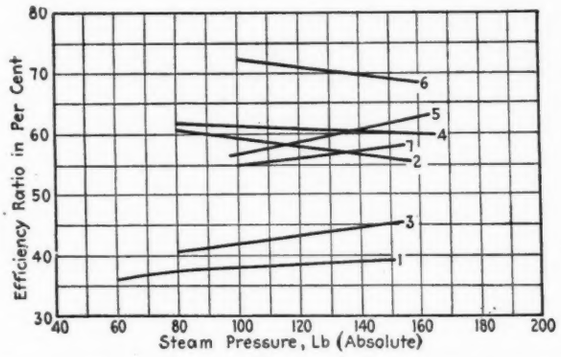


FIG. 4. EFFICIENCY RATIO OF VARIOUS TYPE ENGINES
Curve 1, high-speed engine, 27 in. vacuum; Curve 2, high-speed atmospheric exhaust; Curve 3, four-valve engine, 27 in. vacuum; Curve 4, four-valve, atmospheric exhaust; Curve 5, compound four-valve, 27 in. vacuum; Curve 6, compound four-valve, atmospheric exhaust; Curve 7, 500 kw. steam turbine, atmospheric exhaust.

ture above the temperature of dry saturated steam at any pressure. The total heat in a pound of superheated steam is found by following the desired pressure line until it intersects the line indicating the desired superheat; moving horizontally to the total heat scale gives the heat at this pressure and superheat. As example, a

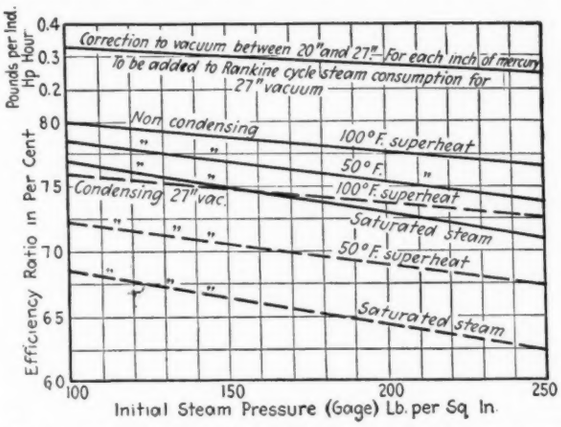


FIG. 5. EFFICIENCY RATIO OF UNAFLOW ENGINES

pound of steam at 100 lb. absolute pressure and 100 deg. superheat is found to contain 1,239 B.t.u.

As has been pointed out in previous articles, during adiabatic expansion the entropy remains constant. Now if we have steam at some initial pressure such as 100 lb. absolute (85 lb. gage), by following down the vertical entropy line passing through the intersection of the 100-lb. line and the saturation curve, it is possible to find the heat left in the pound of steam after expansion to any lower pressure. If the back pressure in an engine is 15 lb. absolute (0 gage) and the initial pressure 85 lb. gage, then tracing downward we find that the 1.60 entropy line intersects the saturated line at the 100-lb. pressure line and intersects the 15 lb. pressure line at a point where the total heat, read from the side scale, is 1,045 B.t.u. The heat an ideal engine would take out in expanding dry steam from 100 to 15 lb. would be 1,186 — 1,045 = 121 B.t.u. per pound of steam.

Problem. The initial pressure of an engine is 135 lb. gage (150 lb. absolute) dry saturated, and the back pressure is 0 lb. gage (15 lb. absolute). The water rate is 25 lb. per indicated horsepower. What is the steam consumption of a Rankine engine for these conditions of initial and back pressure? What is the Rankine efficiency of the actual engine method? Enter the chart at 150 lb. on the saturation curve of Fig. 3. It will be seen by the scale at the side that a pound of dry steam contains 1,193 B.t.u. (the exact value is 1,193.8 B.t.u.). The expansion in the Rankine engine is adiabatic—that

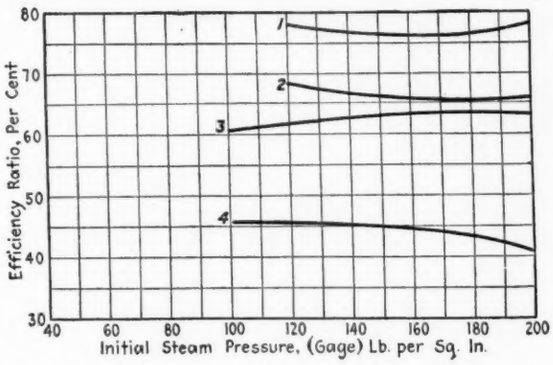


FIG. 6. EFFICIENCY RATIO OF CORLISS ENGINES
Curve 1, compound Corliss, atmospheric exhaust; Curve 2, simple Corliss, atmospheric exhaust; Curve 3, compound Corliss, 26 in. vacuum; Curve 4, simple Corliss, 26 in. vacuum.

is, at constant entropy—so the vertical entropy line through intersection of the 150-lb. pressure line and the dry saturated steam line is followed down until it meets the diagonal 15-lb. pressure line. Reading on the heat scale to the right, we find there is left in each pound of steam 1,025 B.t.u. The heat converted into work is, then 1,193 — 1,025 = 168 B.t.u. Since one horsepower-hour equals 2,545 B.t.u., the water rate of a

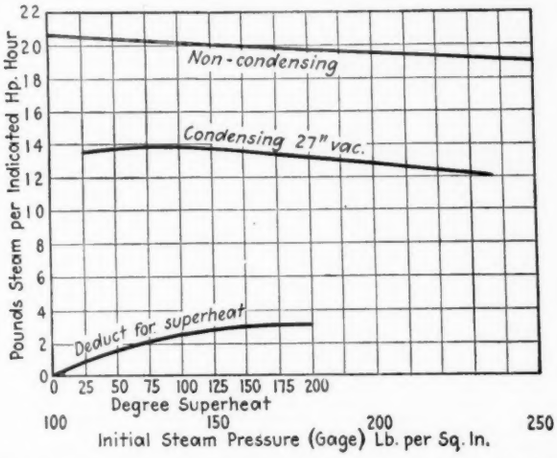


FIG. 7. STEAM CONSUMPTION OF UNAFLOW ENGINES

Rankine engine would be 2,545 ÷ 168 = 15.1 lb. of steam per horsepower-hour. The engine uses 25 lb. per i. hp., making its Rankine efficiency 15.1 ÷ 25 = 60.4 per cent. The Rankine-cycle steam consumption may also be found by spacing with a pair of dividers this distance along the entropy line. Then, keeping the same space between the divider points, this space is

laid out on the scale marked pounds per horsepower-hour at the left side of the chart, measuring from the point *a*, giving, as calculated, a rate of 15.1 lb. This is the quickest method and avoids errors in reading the B.t.u. values. The thermal efficiency of the Rankine cycle is the ratio of the heat converted into work divided by the heat input. Since the boiler is or is assumed to be fed with the condensate at a temperature corresponding to the back pressure, from the total heat shown in the steam at the initial condition of 150 lb. per sq.in., dry saturated steam, namely, 1,193 B.t.u., there must be deducted the heat of the liquid in the water entering the boiler. In the table at the lower right of the chart are given values of the heat of the liquid at various pressures. In our example the back pressure is 15 lb. The heat of the liquid at this pressure is 181 B.t.u. The net heat added to a pound of water to convert it from water at 212 deg. into dry steam at 150 lb. pressure is 1,193 — 181 = 1,012 B.t.u. The thermal efficiency of the Rankine cycle is, then, 168 ÷ 1,012 = 16.6 per cent. The thermal efficiency of the actual engine, since it has a Rankine efficiency of 60.4 per cent, is 60.4 × 16.6 = 10 per cent. This means that of the heat supplied to the engine, only 10 per cent was converted into work and a perfect engine would have converted only 16.6 per cent of this total amount of heat.

Engineers are frequently confronted with the question of the probable Rankine efficiency of an engine. It is possible, if the efficiency of the particular type of engine in question is known, to predict fairly accurately the efficiency and steam consumption of the engine even though it is still in the hands of the draftsman. In Figs. 1-2 and 4-7 are shown the Rankine efficiencies, or the efficiency ratio as it is often called, and the steam consumption of various types of engines for different conditions of initial and final pressures. These curves show the results that may logically be expected from any particular engine. It should be understood that variation in design of cylinder and valves may cause the engine to show a slight increase or decrease in efficiencies from those given in the charts.

Keeping an Oil Film on the Cylinder Walls

By W. F. OSBORNE
Supervisor, Manufacturers' Service, Texas Company

WHEN the oil has been properly atomized and thoroughly distributed throughout the steam, it will be carried to all parts requiring lubrication, including valves, valve rods, cylinder walls, pistons and piston rods. Whether it will adhere to these parts, and remain there as it should to prevent wear and reduce friction, depends upon a great many things.

First of all, the oil should be able to stick to the metal. Any kind of oil will stick to dry metal without any difficulty, unless it is so hot that it is immediately vaporized like water on a red hot plate. If the oil contains suitable constituents, it will soak into the pores of the metal and a glaze will be formed over the surface so that the inside of the cylinder will look like a mirror. Possibly the glaze is assisted by the oil, through the formation of some sort of a chemical compound between the oil and the metal. On the other hand, we find the glaze in marine engines on which no oil has been used at all, the cylinder depending for its lubrication entirely upon the moisture in the steam. Here we cannot say that the glaze is caused by the oil.

Sometimes, when changing from one kind of cylinder oil to another, we find after a few days that this polish has entirely gone from the cylinder wall. A few days later it comes back again, indicating the formation of some kind of a compound on the surface of the metal different for each of the oils. If for any reason the glaze is destroyed and is not quickly re-formed, the cylinder will begin to wear, even though large quantities of oil are used. Every condition should be made as favorable as possible to the formation of a new film, and it always is a good plan when changing from one cylinder oil to another, to feed an excessive amount for a week or ten days so as to assist in the formation of a new polish in case the old one has been dissolved by the new oil.

The polish is also affected by many other things, such as moisture in the steam, alkalies, acids and organic matter which may be brought into the cylinder with the steam from priming boilers. There is also the possibility of rust, scale and other metallic substances getting into the cylinder when steam is first turned onto an engine that has not been operated for some time.

Assuming that the oil will adhere to the cylinder wall in a proper manner, the next question is the amount adhering to the wall and the factors that affect it. Other things being equal, an oil of high viscosity will form a thicker film than one of low viscosity. A thick film of oil naturally will have a better opportunity to prevent the piston and rings from rubbing together in such a way as to cause wear.

The viscosity of course varies with the temperature, and at the temperatures existing in the steam cylinder, the viscosities of all oils are very low. The percentage difference in the viscosities is very nearly as large as it is at 210 deg. F., the temperature at which the viscosity is ordinarily measured, and on this account there is quite a marked difference in the service given by oils of differing viscosities.

From the statement just made that a thick film will have a greater tendency to prevent wear than a thin film, we might be led to believe that high-viscosity oils would be the best in all cases. There is a limit to the viscosity, however, because the high-viscosity oils are not atomized as readily as those of lower viscosities, and instead of improving the film the high-viscosity oil might fail to form a good film at all. This would certainly be the result if all the oil, or a good portion of it, were carried straight out to the exhaust with the steam because it could not atomize properly, owing to its high viscosity. Under such conditions, lubrication could be improved by the use of a lower-viscosity oil.

Temperature has another effect on the oil film, in that, as it reduces the viscosity of the oil, it lowers its resistance to being wiped off the cylinder by the piston and rings. At high temperatures, such as those due to superheated steam, the viscosity is lowered materially, and in order to maintain sufficient oil on the cylinder wall it is sometimes necessary to raise the initial viscosity of the oil.

Surface tension is another physical property of the oil which influences the maintenance of the film. Some oils have a greater tendency to adhere to metals than others. The best oil would be one that would displace the moisture on the cylinder walls, and which in turn would not be displaced by water, should considerable quantities enter the cylinder. The relative surface tension of the oil and metal, with respect to that of water and the metal, is the determining factor in this connection.

Another element affecting the amount of the oil adhering to the cylinder wall is its volatility. The volatility increases with the temperature, so that, at high steam temperatures, a much larger amount of a given kind of oil is required to maintain a proper oil film than at lower temperatures. An oil that is entirely satisfactory at 338 deg. F. (100 pounds pressure) might not be at all suitable at 370 deg. F. (170 pounds pressure) because it would evaporate too fast at the higher temperature. Some engines operate on steam at 200 pounds pressure with 150-200 deg. superheat, and at such temperatures as 538-588 deg. F. any old kind of oil will not do.

Many engineers attempt to select the oil to meet such temperatures entirely on the basis of flash point, assuming that volatility is directly related to flash point. While there is of course a connection between the two, since the flash point is caused by the volatility of the oil, the rate of evaporation or volatilization of two cylinder oils at the temperatures and pressures existing in the steam cylinder may be in quite different proportion from their respective flash points at atmospheric pressure.

The volatility depends upon what the oil is made of and the relative amounts of the different hydrocarbons which it contains. A distillation test no doubt would be more satisfactory for purposes of comparison than the flash test.

An oil that is too volatile will evaporate off the cylinder walls under high temperatures as rapidly as it can be put on by the steam. Furthermore, when the oil is thoroughly atomized and mixed with the steam, it is in an ideal condition for vaporization. Consequently it is quite likely that a considerable amount of vaporization takes place before the oil ever reaches the cylinder walls. Such a state of affairs would require the use of large quantities of such an oil in order to get a satisfactory lubricating film on the cylinder wall.

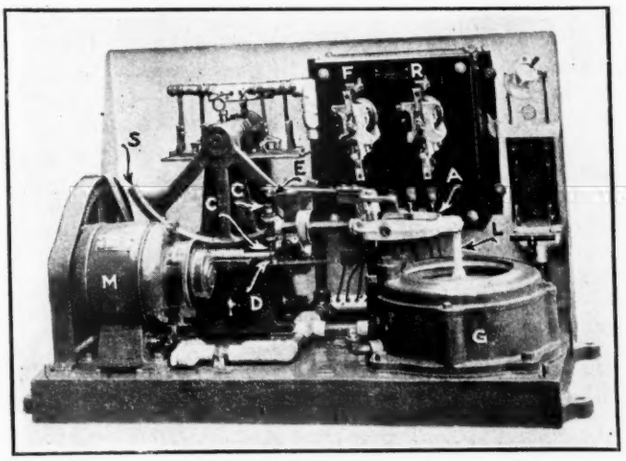
The vapor condenses to a certain extent when the steam brings it into contact with the cylinder, which is at a lower temperature than the steam itself. This condensation aids in the formation of the film. A cold cylinder wall would probably hold a greater film than a hot cylinder wall if it were not for the bad effect of the larger quantities of moisture which would exist on the colder walls.

Other factors affecting the formation and maintenance of the lubricating film are the mechanical condition of the cylinder, piston and rings. When cylinders wear out-of-round, the piston and rings do not fit properly and there is an excessive load on that part of the cylinder supporting the weight of the piston. Worn rings with sharp edges tend to scrape the oil off the wall and permit metallic contact and wear.

When an engine is shut down there is a possibility that the oil on the walls will evaporate, particularly if the cylinder is at a high temperature just prior to shutting down. Then when the time comes to start up again, the cylinder may be dry and rusty. It is always a good plan to increase the oil feed just before shutting down, so that there will be every opportunity for a thick oil film to form for protective purposes until the engine is to operate again.

Northwestern Boiler Damper Control

The regulator shown has been used for about nine years to control gas pressures in byproduct coke oven plants, but only recently has it been applied to boiler plants. Having met with success in this new application of its regulator, the Northwestern Manufacturing Co., of Milwaukee, is now supplying the device to control



AUTOMATIC DAMPER CONTROL FOR STEAM BOILERS

automatically the position of damper, the stoker speed, or both of these functions simultaneously.

Essentially, the regulator consists of a gasometer *G*, a motor *M* geared to a worm sector *S* through a pair of spur gears, and a balanced arm *A* connected at one end to the gasometer bell float by a link *L* and having at the other end a pair of carbon contacts *CC*. At the rear end of the shaft carrying the sector is an arm (not shown) of variable length, connected directly to the boiler damper.

Variations in furnace draft cause the bell float to rise or fall, up for a rise in pressure and down for a drop in pressure. The motor is correspondingly driven in the forward or reverse direction, depending upon whether contact is made with carbon *D* or carbon *E*. The actual motor control is through the forward and reverse contactors *F* and *R*, which are in turn controlled through relay circuits opened and closed by the carbon contacts *CC*. The ratio of the motor speed to that of the shaft is great, so that there is always an abundance of power to move the heaviest damper.

To prevent movement of the damper beyond the wide open or the closed positions, two auxiliary contacts

open the relay circuit at the limit of the travel. Between these points, however, the damper comes to rest at the exact point required to maintain the furnace pressure.

The primary contacts may be adjusted for any variation in pressure, but are usually set to operate on pressure changes as small as 0.01 in. water column. To lessen friction, the float switch is mounted on knife edges. The motor moves the damper slowly so that any change in the damper setting affects the float, and if the change is sufficient to correct the pressure in the furnace, the motor circuit is immediately broken.

To insure proper regulation, a control for each boiler is recommended, since furnace conditions in the individual boiler vary and cannot be subjected successfully to master control from a single regulator.

His Best Cast-Iron Weld

Recently an experienced welder whose knowledge of the industry extends over a dozen years, was asked what, in his opinion, was the best cast-iron weld he had ever seen. Without hesitation he replied, "Wait one minute and I will show it to you."

With that he began delving into a brief case, and presently he brought forth a series of pictures. Some of these pictures are reproduced herewith. A welding engineer who was present remarked, "I know that job. That was done out in Chicago—let me think—why, that must have been five or six years ago."

"It was longer ago than that," replied the welder. "If I am not mistaken, it was either in 1914 or 1915. It was a 7,600-pound gray-iron manifold that was used to connect the exhaust outlet of a large steam turbine with the inlet to the condenser. There were some changes being made in the plant and the casting either had to be cut down or replaced with a new one. A new casting

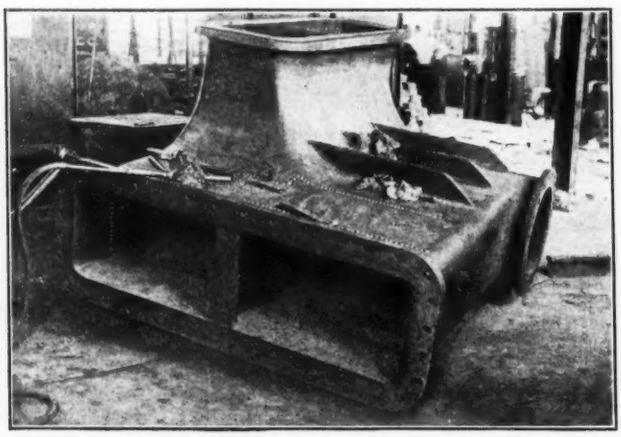


FIG. 1. A SERIES OF HOLES WAS DRILLED ALONG THE LINE OF THE CUT

would have cost several hundred dollars and it would have taken nearly a month to have it made and delivered."

"It would be no trick at all to cut a section out with oxy-acetylene today," interjected a young welder.

"No," agreed the speaker, and he added, smiling reminiscently, "I remember the comments of the day, that it 'was impossible to cut cast iron with an oxy-acetylene flame.' We can afford to smile at that now, when we are cutting gray-iron castings every day with the blowpipe. But I'm getting ahead of my story.

"The general superintendent of the power house for which this work was done first satisfied himself that the casting could be reduced by cutting and welding without impairing it in any way, and that he would save both time and money by having the job done. It was then shipped to the Chicago job shop of the Oxweld Acetylene Company.

"Specifications for the job called for shortening the body of the casting 18 inches. There were three large

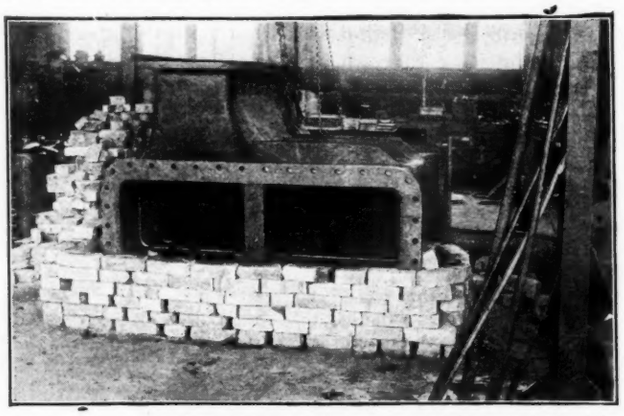


FIG. 2. A BRICK PREHEATING FURNACE WAS BUILT AROUND THE PARTS

flanges, each at right angles to both of the others, and these had to be kept accurately in true, as the slightest warping or error in set-up would render the casting valueless, because of the necessity for steam-tight joints after installation.

"The first thing was to drill an almost continuous series of holes along the line of the cut. This was done with electric drills. Then, after the cut out section was removed, the flange section was set up in

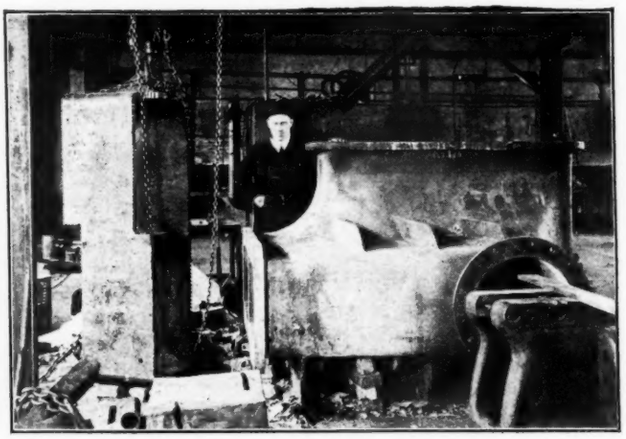


FIG. 3. WELDED CASTING AND SECTION THAT WAS CUT OUT

position to weld to the main body of the manifold. A brick preheating furnace was built around the parts and the whole layout topped with asbestos sheets. The fuel was charcoal and the fire was kept up until the welding was done, the asbestos being opened only enough to give the welders room to work. It took four operators 36 hours, during which time there was no let up on the job. Of course, the casting was cooled down slowly, after which the weld was finished off. The whole thing took only about 12 days, including the 10 days the casting was on the road."

EDITORIALS

The Public Pays the Bill

AS A result of the Cleveland conference the coal strike in the bituminous fields is practically settled. The miners go back to work without a reduction in wages; the operators have successfully held out against a four-state agreement; and the public pays the bill. Such is the net result of the four and a half months' strife in the coal regions, marked by violence such as never before witnessed in this country.

At the outset, when the contract between operators and miners expired on April first, the former were experiencing keen competition from the non-union fields and were out to secure a reduction in wages. One of the most likely ways to secure this was through local wage agreements. Against this the head of the miners' union held out firmly and consistently refused to submit the issue to arbitration.

However, after four months' suspension of production in these fields consumers' reserves have become nearly exhausted and the non-union fields cannot meet more than half the demand. Therefore, the effect of their competition has been temporarily removed and the operators in the union fields will be able to command a price that will enable them not only to meet the wage demands of the miners, but also to return a handsome profit to compensate for the period during which the mines were idle. Against this the public is apparently helpless. As Hoover recently pointed out, the Administration lacks authority to enforce the voluntary price agreement made several weeks ago. Only about seventy per cent of the operators joined in the agreement, and it is idle to expect them to live up to it with the others reaping the fruits of a producers' market.

The one ray of hope that has come out of the Cleveland conference is the provision for a commission to study the whole coal situation and make recommendations to another conference called for January. If this represents an honest desire on the part of both operators and miners to settle the problem definitely, and if each will be prepared to make the necessary concessions to back up the recommendations of the commission, there may be averted a recurrence of trouble when the present contract expires next April. Otherwise, periodic disturbances may be expected.

Chimneys and Breechings

EVERY boiler house has its chimney and its breeching. Yet there are probably less exact technical data available on these parts of the plant than on any other equipment. Many years ago the late Professor Kent collected data on existing stacks that were operating satisfactorily and deduced therefrom certain relations between size of chimney and capacity of boilers on the basis of about four pounds of flue gases per pound of steam. It is to be noted that Kent's formulas are purely empirical and are not based on theoretical considerations. The sizes of boilers, breechings, and chimneys have been greatly increased in recent years, and in many cases the weight of flue gases per unit of capacity has been materially reduced below Kent's figures. Reliance can, therefore, no longer be placed on these formulas without giving careful consideration to local plant conditions. Even then they merely serve as a guide to the designing engineer, who uses largely his own judgment in choosing chimney size. In fact, it is common practice to base chimney proportions on other stacks that are known to function satisfactorily. This whole procedure is irrational and unscientific.

Several laudable attempts have recently been made to develop rational formulas for chimneys based on theoretical considerations, but these have not been coordinated with data representing actual practice. Research work on the relations between height and draft with different types of chimneys and between chimney area and boiler capacity would be welcomed by all engineers. Friction losses in chimneys and flues are practically unknown quantities, although Weymouth has done some splendid work along this line with chimneys on oil-burning plants in California.

When breechings are lined, there is the question of the most suitable material for lining. Also there is the economic problem regarding the cheapest and most satisfactory flue construction, round or rectangular, with flat or rounded tops.

Wind loads must be carefully considered in chimney design. Many new chimneys are built on a mat above the boilers and supported by structural steel columns. Such steelwork must be amply braced to prevent excessive chimney sway in high winds. Particular attention must be given to this factor for all chimneys built in the tornado belt that extends through the Middle West and South.

What France Thinks of Superpower

WHILE our Superpower project is still in the balance, the latest step of the French government will come as a real surprise to American engineers. A law has been passed and made public on July 21, 1922, authorizing the French government to build a network of high-tension transmission lines throughout the country, and to compel private generating and distributing companies to interconnect their systems through this network "whenever such a move may be expected to result in better utilization of the available energy, both steam and hydraulic." Furthermore, if for any reason it appears inadvisable for the government to undertake the construction of all or part of the high-tension system, it can compel the private companies to co-operate, under the direction of the state, to build the lines, the government to subsidize the undertaking if necessary.

This law is evidently meant to be enforced, strange as it may seem. Should any private generating or distributing company, whose co-operation is deemed necessary by the Minister of Public Works, refuse to comply with the terms of the law, the state will take over the company's property, either by direct purchase or by

expropriation, operate it and take the company's place in the construction work that may be under consideration.

In order to fully appreciate the progress indicated by this law in the ideas of the French business and industrial men, it should be emphasized that, of all nations, France is perhaps the one in which the individual is the most jealous of his personal rights and unwilling to combine forces with his neighbor, for fear of alienating his personal liberty. Hardly one year ago a project for superpower development was presented by two engineers in the *Revue Générale de l'Electricité* and commented on in *Power*, in which it was proposed to transmit the energy at high-tension to the centers of utilization, but not to interconnect either the transmission or the distribution systems at the receiving end, in order to safeguard the interests of the individual distributing companies. Thus all the benefits of interconnection, with its vast advantages in security and continuity of service, were to be sacrificed, so as not to alienate the liberties of these companies.

But the high cost of coal, the adverse foreign exchange and other financial difficulties are stern masters, and the country must progress or be dropped. It is proposed now to ask Germany to undertake in France, as she has been doing at home, a huge plan of national development, in part payment of those elusive reparations. Foremost on the list are the superpower network and the development of the Rhone and Dordogne valleys for hydro-electric power. If this proposition is accepted, the question of "superpower or no superpower," which is troubling our Atlantic coast region at the present time, will solve itself, for we will only have to go over to France to see it work.

Operating Convenience in Queenston-Chippawa Plant

IN THIS issue the leading article describes the power house of the Queenston-Chippawa development of the Hydro-Electric Commission of Ontario. This installation has been laid out for six hundred thousand horsepower and utilizes on the turbines three hundred and five feet of the three hundred and twenty-seven feet fall between Lake Erie and Lake Ontario, or over ninety-three per cent of the total head between the two lakes. In point of efficiency over eighty-four per cent of the total energy of the water due to the three hundred and fifteen feet head utilized in the system is delivered at the station busbars. Although the development stands without a parallel in point of efficiency, the operating features have not been neglected.

While in many plants the entire unit has to be dismantled to remove the turbine runner, at Queenston provisions have been made for doing this from below the casing and then transporting it on a car to where it can be raised to the erection or repair floor by one of the power-house cranes. The removal of the runner has been considerably simplified by making the turbine and generator shafts hollow so that one of the power-house cranes may be utilized in lowering and raising the runner from and to the casing. Although this is not the first time that this scheme has been used, it possesses much to recommend its wider adoption with large hydro-electric units.

A novel feature in design of the plant is the placing of the main generating-room floor on a level with the top of the generator frames, a construction that provides below this floor space at small cost for the exhaust-air ducts, fans and generator-field equipment adjacent to the unit, and it still allows a clean space around the generator on the main floor. This arrangement has made the entire generator-room floor space available where the actual operation of the machine is centered; namely, at the top of the generator. Here is also located the governor control stand, of special design. On it is all the equipment necessary to give the floor operator complete control of the unit at all times and at the same time keep in touch with the chief operator in the control room. The units are so large that they constitute in themselves a good-sized power plant, so that the importance of the operator having complete knowledge of the operating conditions and positive control of the unit at all times, as well as a convenient arrangement, is apparent.

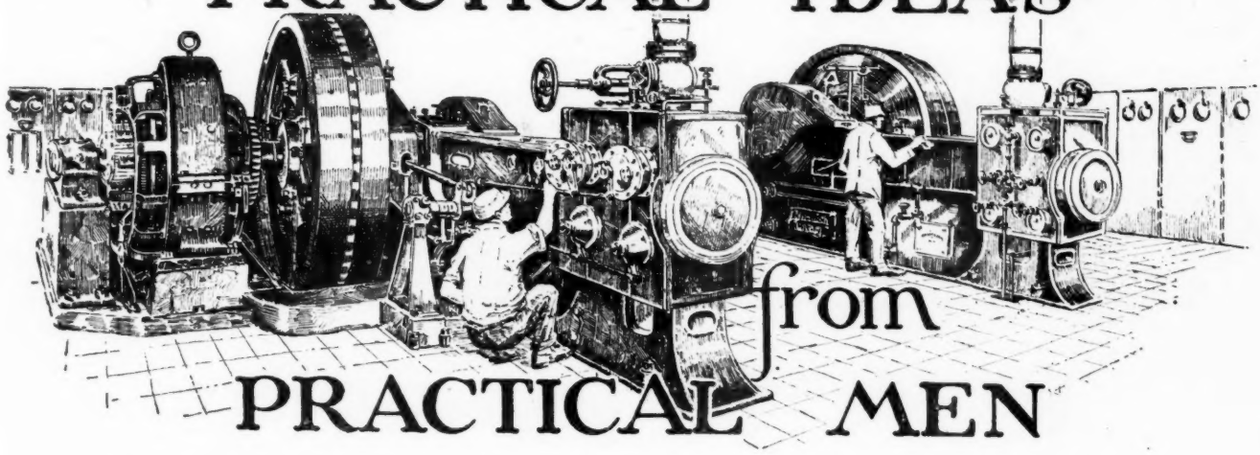
The great weight of the equipment on account of its size makes it necessary that wherever possible it be handled by power-house cranes. This facility has also been provided for the main transformers, which are mounted on roller-bearing structural-steel trucks set on rails. A track runway throughout the length of the building permits moving the units out under the power-house crane on the generator-room floor. Many operators will call this easy compared with handling such equipment with chain falls and jacks.

As in many other modern stations the unit system has been adopted at Queenston, and it has been carried out to a greater extent than in any other plant. Each fifty feet longitudinal space in which the turbine and generator are situated contains the step-up transformers, high- and low-voltage oil switches, fans and reactors. This has not only simplified the plant's construction, but has contributed to its operating convenience.

The initial installation of the Queenston-Chippawa plant is now nearing completion and will stand as another mile post in hydro-electric engineering. In efficiency little improvement can be expected over that attained in this development. There remain, however, excellent possibilities for improvements in design that will reduce the cost of construction and yet retain the high standards of efficiency and reliability incorporated in the latest Niagara development. In this direction much may be expected, and promising developments have already been started.

"Everything is shipshape." It is an old expression which means a lot because the sea is a treacherous servant that one day helps with a fair wind and tries the next to send everything to the bottom. The wise captain uses the periods of good weather to put his sails, spars and gear in perfect condition. He knows that he may be too late if he waits until the gale strikes him. In this respect a power plant is much like a ship. The engineer who repairs his equipment before it breaks and who uses the fair days of smooth running to get things lined up for any emergency that may arise is the man most likely to finish the yearly "voyage" with the "ship," "crew" and "cargo" intact and with himself in line for substantial recognition. This principle has been put to use in a number of plants during the industrial depression of the last year and they are prepared to take on the load imposed by increased industrial activity.

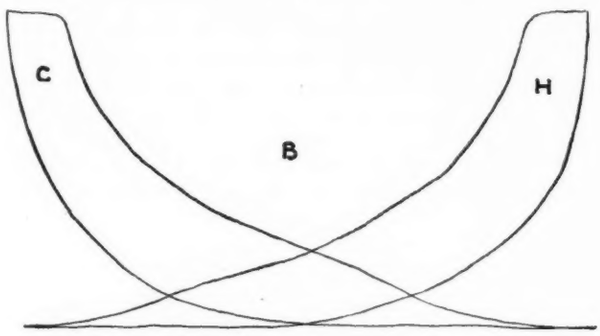
PRACTICAL IDEAS from PRACTICAL MEN



Peculiar Steam-Engine Diagram

I am operating a unaflow steam engine running at 150 r.p.m. Upon taking indicator diagrams I obtained a number that are similar to the ones in the illustration.

I would like some *Power* reader to tell me why the expansion line has the sharp change in curvature long



UNAFLOW DIAGRAMS SHOWING EARLY RELEASE

before the end of the stroke. It would seem that release takes place much before the piston uncovers the exhaust ports. The engine exhausts against atmospheric pressure, and is equipped with auxiliary exhaust valves.

Jersey City, N. J. JOHN A. CASS.

Burning Coke Braise with Natural Draft

Coke braise, or coke dust, when used for fuel under boilers, is very difficult to handle in other than specially designed forced-draft chain-grate stokers. These difficulties have been overcome, and coke braise is used to replace coal in a plant of seven boilers outfitted with chain grates, eight feet wide by ten feet long, operating on natural draft.

From the same source as the coke braise a limited amount of coke-oven gas was available, and a combination of the two, in the proportions of ten thousand cubic feet of gas to one ton of braise, has realized its use without forced draft, successfully.

Gas and coke of analysis shown in the table and used in the proportions mentioned gave a combination in which the gas replaced the volatile matter in coal and kept the temperature of the arch up high enough to give the required ignition temperature for coke.

A few changes in the stokers were deemed necessary, these being to put a ¼-in steel plate under the chain for the first twelve inches past the edge of the fuel gate and the full width of the stoker, to decrease the amount of air coming up through the grates at this point, as the air required is now supplied from above with the gas.

The stoker was backed out and eight 2-in. pipes were embedded in the face of the arch, extending through from the top and flush with the bottom side of the arch

ANALYSIS OF COKE BRAISE AND COKE OVEN GAS

*Coke Braise**		*Coke-Oven Gas*	
Carbon	79.49	O_2	0.004
Ash	17.66	C_2H_6	0.022
Volatile	2.85	CO	0.064
		CO_2	0.021
Sulphur	0.94	CH_4	0.235
B.t.u. (Dry)	12,617	H_2	0.615
		S	0.003
		N_2	0.036

*Moisture as fired, average 15 per cent.

or the roof of the furnace. The stoker was then run back under the tubes with the 12-in. baffle under the grate, as previously described. A 2-in. gas manifold was placed on top of the arch with welded outlets at each of the eight 2-in. pipes placed through the arch, and a ⅜-in. gas jet was placed in each of the 2-in. pipes. The gas was supplied at an average pressure of 2 lb. gage, and was controlled by one valve placed at the side of the boiler.

To start the boiler in operation, the valve was opened and the gas ignited with a shovel of burning coal placed through the fuel opening under the fuel gate, the hopper was filled with coke and the grate started. As soon as the coke started under the fuel gate, it was ignited by the gas and regular boiler operation ensued.

The first operating difficulty encountered was the fusing of clinker to the side wall at the level of the fuel bed. This difficulty was overcome by running down the fire once per shift and knocking clinkers from side wall with bar. This was later remedied by placing a water box along the edge of the stoker, embedded in the side wall, and passing water through it to the heater. The only other difficulty encountered was the large amount of fine ash that was carried over into the stack base. This was cleaned out weekly by means of a chute discharging directly to the ash conveyor car.

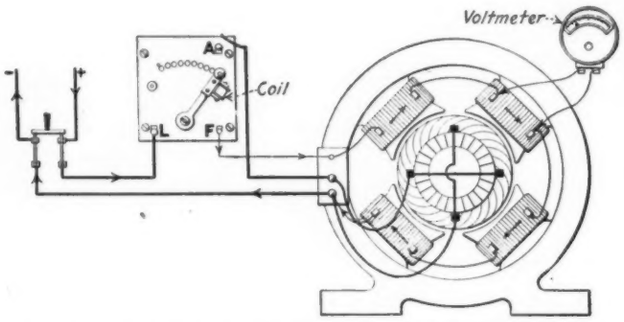
Using gas and coke in the proportions stated, with an over-fire draft of 0.35 in. of water and a 6-in. fuel bed, the average results were a stack temperature of 540 deg. F., CO_2 at stack base of 9.5 per cent, and a carbon content in the ash of 38 per cent.

The labor requirements were the same as on coal, and the efficiency obtained was slightly better than that reached under average conditions on coal burning. One attractive feature of this operation is the ease of convertibility to which the boiler is subject. Either coal or coke braise may be burned in these stokers with little time lost in the process of conversion, especially if coke is kept at a low level in the hopper when gas service becomes irregular. C. W. FISHER.

Lakewood, Ohio.

Locating Defective Shunt-Field Coils

A 7½-h.p. 500-volt motor was sparking considerably on the commutator. The brushes were shifted and the spring tension changed without any improvement in



TESTING FIELD COILS FOR SHORT-CIRCUITS WITH A VOLTMETER

operation. The line current was measured with an ammeter and the revolutions per minute determined and both found to be correct.

The four field coils were then tested for heat and voltage drop. All the coils were hot, and the voltage when measured at the terminals, as indicated in the figure, showed considerable variation. The coils were opened and found to have absorbed moisture, which had caused portions of them to be cut out of circuit.

The brush sparking was caused by the field poles having different magnetic values on account of the coils having a different number of active turns. The armature speed remaining correct is accounted for by the fact that the resultant magnetic field would remain practically the same. As the turns were cut out, the resistance would decrease and the current would increase in direct proportion, thus maintaining the ampere-turns practically constant.

Newark, N. J. A. BRAME.

Changing the Lead

So you want to give your engine a bit more lead, on account of the increase in speed that you have decided upon, and don't know how to do it because the eccentric is keyed to the shaft

Sensible engine builder, that. He sold that engine to run 150 turns and keyed the eccentric on at the proper angle ahead of the crank to give good steam admission at that speed, with the lap that he put on the slide. If he used setscrews, you or someone else would have had the shaft spotted and scored about halfway around, experimenting with more lead and less lead; especially if the setscrews had (as they usually have but never should have) pointed ends. But now that you have run the speed to 200, perhaps it would be wiser to slip the sheave ahead a bit; but you are in a quandary about how to do it without going to a lot of trouble and then perhaps doing a bad job.

"There are more ways of killing a cat than choking it with butter," and there are few jobs of which it can be said that there is only one way to do them—or even one very best way.

You could, for instance, discard the key entirely and drill and tap a hole for a setscrew, and use it with a cupped end, leaving a sharp ring to bite the shaft.

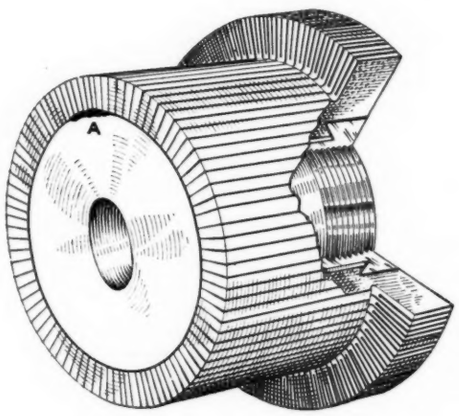
Another way would be to cut another keyway in the shaft and sheave near the old one on the shaft and not so many degrees ahead of the old one in the sheave. Or you could widen one keyway in one direction and the other one equally in the other direction and use a wider key—or (not so good) two keys. Or you could leave the keyways the way the builder put them and use a stepped key. That is the way that I recommend, so that any time you want to come back to the original angle of advance, all that will be necessary will be to change back to the old plain key.

If you ever want to make this or any other engine run under, what I have just told you might come in handy. ROBERT GRIMSHAW.

New York City.

Repairing a Commutator

The commutator of a 3-hp. 500-volt motor had a large hole burned in the front mica end ring, as at *A* in the figure. The hole when cleaned ran back under the bars about ½ in., and was about ¾ in. wide. It was intended to open the commutator and put in a new ring, but to do this it would have been necessary to remove all the leads from the bars and the commutator from the shaft,



DEFECT IN COMMUTATOR AT *A*

as the commutator had to be opened from the inner side. Owing to the limited time available, this could not conveniently be done, so an emergency repair was made.

The hole was carefully cleaned of all carbonized mica and oil. Several attempts were made without success to fill it with commutator cement. Then sheet moulding mica was fitted in such a way as to stagger the joints at the edges. The commutator was then thoroughly shellacked and dried with a torch. A 110-volt test showed no ground. The armature was then baked for ten hours. This machine has since been running 18 hr. per day without giving any trouble.

Newark, N. J. A. HEARVEY.

Symbol Should Be Used on Power Boilers Only

The Boiler Code Committee has been informed that in some cases the official stamp or symbol shown in Fig. 23 on page 87 of the Boiler Code, which should be used only on power boilers, has been used on low-pressure boilers, and I have been instructed to send the following notice to all manufacturers to whom the stamp has been supplied:

The symbol shown in Fig. 23 (and illustrated herewith) is authorized for use on power boilers only.

As stated in section 377 of the Code, all heating boilers built in accordance with the rules in the Code should be marked "A.S.M.E. Standard," using letters and not the symbol.

Misuse of the symbol constitutes a violation of the affidavit made at the time the stamp was issued, and will serve as grounds for denying the further use of and for recalling the stamp. C. W. OBERT,

Secretary to the Boiler Code Committee.

New York City.

Testing Boiler Waters

Having read several articles in *Power* on testing boiler water for corrosion and the proper treatment, I thought it would be of interest to stationary engineers to know how the marine engineer takes care of the various feed waters taken aboard at each port of call.

A testing outfit widely used in marine practice and giving good results is the "Erfmann Boiler Water Controller," a simple apparatus by means of which any person can, without chemical knowledge, at any time and in a few minutes determine the correct proportion of soda ash for any boiler water to keep it in a neutral condition. Boiler water is in a neutral condition when it is neither acid nor alkaline.

If the water is not acid, it eliminates corrosion, pitting and galvanic action; if it is not alkaline, it also eliminates corrosion, as well as priming and foaming. By keeping the boiler water in a neutral condition, it is neither corrosive nor does it cause incrustation of scale on the heating surfaces; and by having clean boiler tubes, the boiler efficiency is increased anywhere from 10 to 15 per cent.

The only correct way to keep the boiler water in proper condition is to test it regularly by some standard method. The controller mentioned is a small, compact, complete portable testing outfit containing two glass tubes, one graduated, the other plain, a receptacle, a box of filter papers, a bottle of solution containing methyl orange and soda ash and a bottle of standard solution of sulphuric acid.

The engineer, on receiving a new supply of feed water, tests it and determines its neutral point. He then tests his boiler water and checks up the reading. If the reading comes below the neutral point of the feed water, he must add a certain definite amount of soda ash to bring the boiler water up to the neutral point. However, in case he is using soda ash and the reading comes above the neutral point, he has too much soda ash in the water. Too much or too little soda ash will cause just as much trouble to a boiler as no soda at all. A. L. WERNERT.

New York City.

Oil Engine vs. Steam Power

In reading Dr. Lucke's article, "Oil Engine vs. Steam Power," in the July 18 issue, I was disappointed to find no credit given the steam plant for its byproduct low-pressure steam. I realize that the demand for exhaust steam is so variable that no set credit can be given, but each case has to be considered by itself.

In plants where no low-pressure steam is needed for process work or for heating, there would be no credit due; but at the other extreme, where the demand for low-pressure steam equals or exceeds that supplied by the engine exhaust, the power might well be considered the byproduct of the steam plant.

These are two extreme cases, but they are both found in practice, and in almost all industrial plants some steam is used for process work or for heating.

No one can dispute the fact that the thermal efficiency of the oil engine is very much higher than can be obtained from the steam plant figured upon a strictly power basis. But on the other hand, the thermal efficiency of the steam plant taken as a whole, where all the exhaust steam can be used, is much higher than can be obtained from the oil engine.

In determining the relative cost of power between the oil engine and the steam plant, one would have to figure along the same lines as when figuring between the central station and the isolated plant, with this exception—the overhead expense of the oil engine should be charged against it to determine the cost of power, while the overhead expense of the central station would be included in the rate given; or, in other words, where steam is used for power through the heating season, as is done in some cases, and other power used the rest of the year, it would be necessary to bear the overhead expense of two plants throughout the year if the oil engine is used during the summer months.

No one can say which power is the cheaper without going into all the details of each individual case. This is such a complex problem for the novice that a good many plant owners are misled. They find out their mistakes only after paying the bills for a year or more.

The oil engine also rejects large quantities of heat, and it is my opinion that this heat might be used in some cases to do the necessary work. I know it has been used in a few cases, but it is not so easily made available as is the heat from the steam engine, and the heat carried away by the cooling water is of too low temperature to be of much use. W. D. THROOP.

Norwich, Conn.

Heat Balance at Gennevilliers and Hell Gate

My second article[1] on the Gennevilliers Station compared the method of heat-balance control at this plant with that at the Delaware and Colfax stations in America and the Dalmarnock station in Scotland. The following, which may be considered as a continuation of the aforementioned article, gives a similar comparison for the Hell Gate station with incidental mention of the Calumet station.

The Calumet and Hell Gate stations have followed the lead opened by the Delaware station. It will be remembered that the impulse turbines of the latter were provided with a bleeder connection for feed-water heating, but that this had not been used, apparently in order to avoid the installation of a closed heater.

In the Calumet Station the feed water is first heated in a closed heater with steam bled from the main turbines, then in an open heater with the exhaust from steam-driven auxiliaries.

Practically all the auxiliaries in the Hell Gate Station are electrically driven, either from the main bus, through station transformers or by a house turbine. The feed water is first heated to about 150 deg. F. in a closed heater, with steam bled from the main turbines at about 7 lb. absolute pressure at full load. It then goes through an open heater, where it is heated by the exhaust from a house turbine and from a few steam-driven auxiliaries, to approximately 210 deg. This heater operates under a slight pressure—about one pound gage—and the vent is therefore probably closed by means of a safety valve set to open at this pressure.

Thus far the heat-balance system of this station is closely similar to that of the Dalmarnock plant in Scotland. However, the novel point about it is that this heater is also connected to the main turbine through a second bleeder connection, at a point where the steam pressure in the casing at full load is apparently slightly more than one pound gage. If, under a rising load, the amount of feed water to be heated increases more rapidly than the available heating steam, so that it tends to condense all the exhaust from the house turbine and to lower the pressure in the heater, steam is automatically drawn from the main turbine to make up the deficiency and to keep up the final temperature of the feed water.

From the viewpoint of the use of the house turbine, the Hell Gate Station is a marked departure from the Colfax and Dalmarnock plants, in that the house turbine is not connected in parallel with the main bus. The auxiliaries can be switched individually from the station-transformer bus to the house-turbine bus, but these two buses are not electrically connected. The reason for this is that the fine load adjustments necessary to maintain a constant feed-water temperature are no longer made on the house turbine, but are automatically made by the main turbine through its upper bleeder connection. The Hell Gate house turbine is less important to the plant than that of Colfax and more important than that of Gennevilliers. From the viewpoint of continuity of service it does not give the security or the service that the Colfax turbine gives, for the latter is ready at all times to pick up the load of the auxiliaries without interruption in case of trouble from the main bus or the station transformers; or, in case of trouble with itself, to surrender this load instantaneously to the station transformers. The Hell Gate house turbine is simply a stand-by in continuous operation, and a brief interruption will be unavoidable, in case of trouble, before the auxiliaries can be switched over from one bus to the other. On the other hand, being protected from trouble arising from frequency fluctuations and disturbances on the distribution system, it has gained a certain reliability.

In the heat-balance system, the Hell Gate turbine has also taken second place. In the Gennevilliers Station it has been eliminated from the heat-balance system and, at least for the present, is not to be operated during the daytime. In other words, it is practically discarded. It will be interesting to see if American practice will follow the French in this respect, and whether the house turbine is passing out of favor.

From the viewpoint of the regulation of the feed-water temperature, the heat-balance control of the Hell Gate Station is unquestionably superior to that of Gennevilliers, for not only is the final temperature of the feed water kept rigidly constant, but this is accomplished almost automatically, with little hand adjustment. The Gennevilliers system takes more steam from the main turbines and less from the auxiliary source. Inasmuch as both the weight and the heat content of the bleeder steam decrease with the load, the total heat available from this source for feed-water heating will decrease much more rapidly than the weight of feed water, and the temperature of the latter will drop as the load goes down. In fact, the water goes to the hotwell at 194 deg. at full load, and at 167 deg. at half load. It seems unlikely that the three steam-driven boiler-feed pumps exhausting into the hotwell will be able to equalize, even approximately, the final feed-water temperature. If all three are operated continuously, they will, on the contrary, add to the temperature variation with the load.

It should be noted, however, that if a constant feed-water temperature appears desirable in the course of operation at Gennevilliers, this station contains all the necessary elements to secure it. One way of accomplishing this would be to use the duplex drive of the circulating pumps, as in the Delaware Station, as an adjustable source of exhaust steam with which to make up for the deficiency of bleeder steam under light loads.

Though from the viewpoint of temperature regulation the Hell Gate heat-balance system is superior to that of Gennevilliers, the latter remains thermally the more efficient of the two, for two reasons:

First, since at Hell Gate the upper bleeder connection is only to be used to supply the deficiency in ex-

[1] Published in the Aug. 15 issue of *Power*.

haust steam, the weight of heating steam drawn from this source will probably never be more than a small fraction of that which the feed water could absorb between the temperatures of the lower and upper bleeding points, if the house turbine were shut down. The heat supplied by the house-turbine exhaust therefore represents so much heat available from the main turbine, that is wasted in the condensing water.

Secondly, it is advantageous to make the bleeder steam work as long as possible before using it for heating. In other words, the bleeding points should be as near as possible to the condenser. It is in fact, doubly important to use the steam in the lower stages whenever possible, because the wheels in these stages are ordinarily made of larger diameter than in the upper stages, in order to give a wider path for the low-pressure steam. Now the work available from the steam in each stage of a turbine varies approximately as the square of the mean diameter. Thus, in the Gennevilliers turbines, the steam does twice as much work in each of the three last stages as in each of the seven first. To neglect using one of these low-pressure stages is therefore equivalent to neglecting two of the high-pressure stages.

An alternate arrangement in the Hell Gate Station might have been to bleed the main units at pressures of about 3 and 7 lb. absolute, instead of 7 and 16 lb., and to use the house-turbine exhaust alone to raise the feed to the final temperature. However, this would have required an extra closed heater, and if the temperature regulation were to be automatic, as in the present system, an automatic valve on one of the bleeder connections, controlled by a thermostat or by the pressure in the open heater. Or, better yet, the bleeder steam might have been used in full, and the house turbine connected in parallel with the main bus, to be used as in Colfax, to supply a variable amount of exhaust.

But it must not be forgotten that the conditions of the problem in America, where coal is cheap and money is dear, are quite different from those in France, where coal is three times as expensive as in the United States and capital is somewhat cheaper. It would not be surprising if coal-saving equipment could pay for itself four times as fast in a French plant as it would in an American plant of the same capacity. In all engineering work "dollar" efficiency is a compromise between scientific efficiency and simplicity and reliability. In power-plant practice the compromise will lie closer to scientific efficiency in France than in America, at least while present economic conditions prevail.

Paris, France. R. H. ANDREWS.

Standardization

Allow me to compliment you on your foreword in the July 25 issue. There has been a great deal of talk about standardization of catalogs as well as the standardization of apparatus that is manufactured. When one looks at the pile of mail that comes in and sees everything from 2x10-in. to 12x14-in. one wonders how the average manufacturer expects a man to think enough of this stuff to keep it in sight any longer than getting it to the waste basket.

There are many things that are being put on the market that are so new that present-day handbooks have nothing concerning them. There are also many standard pieces of apparatus, the details of the operation of which and the savings or service which may be expected from their installation, cannot be included in fairness to other manufacturers. Frequently I find in some of these catalogs just such information in the form of tables and charts, which I would be glad to keep. To do this one must have a big catalog file or else have the data copied on a standard-size sheet for filing.

From my viewpoint the manufacturers would certainly be doing a favor if they would choose certain sizes suitable for the standard lines of ring binders that now may be bought anywhere in the country and issue their material ready punched for filing in these covers; and it would be to the mutual advantage of every company if the data regarding their apparatus were sent out in such a form as to be conveniently filed.

Brunswick, Me. S. B. JONES.

Comparative Tests on Coal and Oil

With reference to S. A. Smith, Jr.'s reply in the July 25 issue to my comment in the July 4 issue, I am still of the opinion that the results given have a narrow application to that particular plant as it was, and are not a fair comparison of the cost of making steam by coal and by oil.

An efficiency of more than 53 per cent with coal, and a draft in the uptake of 0.2 in. of water would be surprising, when burning 16 lb. of coal per square foot of grate per hour. The draft loss through boiler and setting at normal rating would be fully as much. Attempting to burn this amount of coal with only one-half the necessary draft would result in low efficiency.

With oil fuel the entrainment of air with atomized fuel could easily increase gas movement equal to $\frac{3}{16}$ in. additional draft, and mix fuel and air thoroughly, although this increased pressure could not be measured and exists in only a part of the combustion space.

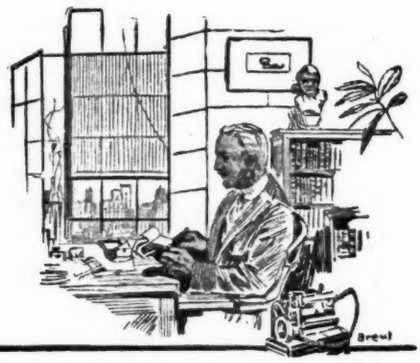
I do not think the presence of 0.44 per cent CO has any great influence on the efficiency. Oil contains three times the hydrogen that coal does, and with equal amounts of excess air it could be expected to waste more than coal. The loss through latent heat and superheat in the products of combustion would also be larger. Changing the position of the damper has a great effect on capacity of the boiler and very little on efficiency. I have seen several hundred analyses where the draft was reduced from $2\frac{1}{2}$ in. to $\frac{3}{8}$ in. with an increase of CO_2 of one per cent and the difference in CO within probable error of observation (less than 0.1 per cent).

On the other hand, I have never known, with hand firing, any disturbance of the fuel bed by bars or rakes, which did not cause evolution of CO for several minutes, even with 3 in. draft, and fires adapted to that draft, when burning 20 to 45 lb. per sq.ft. of grate surface per hour.

One of the things noticed, with daily regularity, was that after about two hours of full load the CO_2 readings would suddenly drop and the CO increase in the same proportion; and if no changes were made in the fire these readings would change in less than half an hour from 16 per cent CO_2 and a trace of CO to 8 per cent CO_2 and 8 per cent CO. The remedy was to thoroughly bar up every part of the fire when the drop in CO_2 was first noticed, and after about 15 minutes the CO would be all burnt off and no further barring would be necessary for possibly three to five hours. This was done regardless of the amount of load on boilers at the time.

Lawrence, Mass. THOMAS F. WALSH.

QUESTIONS AND ANSWERS



Red-Hot Steam Pipes

Will steam pipes get red hot from superheated steam? R. H.

Superheated steam may be of high enough temperature to make the pipe appear red hot, and that appearance of parts of piping systems has occurred during darkness of night in plants operated by steam at 250 to 300 lb. gage pressure and about 350 deg. of superheating, with the steam temperatures ranging between 756 and 770 deg. F. This is to be expected, since to most observers solid substances give out a red glow in the dark, when heated to the temperature of 752 deg. F.

However, to be visible in twilight requires a temperature of 885 deg. F.; in daylight, 975 deg. F.; and for a red glow to be visible in sunlight the temperature needs to be 1,077 deg. F., which is the temperature of steam at 535 lb. gage pressure when superheated 600 deg. F. above the saturation temperature.

Working Pressure of Boiler Based on Strength of Longitudinal Seam

What would be the safe working pressure, with a factor of safety of 5, for a boiler 60 in. in diameter made of ½-in. plate of 50,000-lb. tensile strength, and longitudinal seam 56 per cent efficiency? S. B.

Based on the strength of the longitudinal seams, the maximum allowable working pressure is determined by the formula,

$$P = \frac{TS \times t \times E}{R \times FS}$$

in which

P = Maximum allowable working pressure, lb. per sq.in.;
TS = Ultimate tensile strength of shell plates, lb. per sq.in.;
t = Thickness of shell plate in weakest course, in.;
E = Efficiency of longitudinal joint;
R = Inside radius of the weakest course of the shell, in.;
FS = Factor of safety allowed.

Assuming from the data that $TS = 50{,}000$ lb., $t = \frac{1}{2}$ in., $E = 0.56$, and $R = 60 \div 2 = 30$ in., and substituting in the formula, gives,

$$P = \frac{50{,}000 \times \frac{1}{2} \times 0.56}{30 \times 5} = 46.6 \textit{ lb. per sq.in.}$$

Motor Trouble from Flexibility of Mounting

In a shunt-wound 35-hp.-d.c. motor geared to a variable load, the armature occasionally rubs on the polepieces and loses the binding wire. The air-gap clearance between the revolving armature and stationary polepieces has been increased slightly over the normal amount and evenly adjusted. New bearings and field coils were installed, but the trouble continues. The armature winding is well done, and our repair department has failed to discover the trouble. What is the cause and remedy? R. S. A.

The trouble probably originated in the method of installing the motor. Since the motor has been practically renewed without improvement, it is evident that the motor itself is not at fault.

Cases have been known where geared motors were not solidly bolted and clamped down, so that sudden loads caused the gear wheel to be forced away from the pinion, resulting in deflection of the shaft and springing of the armature against one side of the field. If you will see that the pinion is accurately lined up and that the foundation and bolting of the motor are secure, without any "give" at the pinion, we believe the trouble will be overcome. A new set of foundation bolts may be necessary, or perhaps some reinforcement of the foundation may be required. Be sure that the armature runs true and that the air gap is equal on all sides, with as small bearing clearance as possible. Test the pinion to see that its bearing is rigidly held in place.

Trouble from Leak in Pump Suction Line

Is any trouble or damage likely to result from leakage at a coupling in a 3-in. galvanized suction pipe to a duplex pump? The pipe line is 300 ft. long and placed 4 ft. underground. J. R.

Unless the quantity and pressure of the water supply at the point of leakage are sufficient to maintain pressure above the atmosphere when the pump is operated, the leak is likely to give trouble from air being drawn into the pipe, causing the suction line and pump chambers to become airbound. This would result at least in impairment, if not complete nullification of the operation of pumping, which might have serious consequences where the pump is relied on to furnish water for boiler feeding or for extinguishing fire.

The maximum rate of pumpage should not require a greater velocity of water in the suction line than 240 ft. per min., and with that velocity a tight 3-in. pipe would deliver about 90 gal. per min. With this rate of flow the loss of pressure from pipe friction would be not less than 3 ft. of head per 100 ft. length of the pipe, and in addition about 1 ft. of the head would be required for entrance and velocity. Hence when the pump displacement is as much as 90 gal. per min., the total head of suction water above the point in the line where the leak is located must be more than 0.03 of a foot for each foot in length of suction pipe measured from the intake to the leak, plus 1 foot for the required entrance and velocity head; otherwise the pressure will go below the pressure of the atmosphere and trouble

will be experienced from air entering the leak in the suction pipe.

For example, a bad joint in the suction line 210 ft. from the entrance will give trouble from air leakage unless the point of leakage is at least $(210 \times 0.03) + 1 = 7.3$ ft. below the free water level at the entrance while the pump is in operation. However, for a slower rate of pumpage or for a greater head there would be damage only from outward leakage of water and no air trouble from the bad joint in the suction line.

Setting Piston Valve

How is the valve setting done on an automatic engine that has a piston valve with inside steam admission?

R. N. G.

First get reference marks on the flywheel corresponding to the dead-center positions of the piston.

For that purpose turn the engine in the direction it should run until the piston is within about one inch of the end of the stroke. Then tram from some fixed point, such as a point on the foundation, or sub-base, to the edge of the flywheel, and make a center-punch mark at each end of the tram. Now make a mark on the lower crosshead shoe and one to correspond with it on the lower guide and turn the engine forward until these two marks again coincide. Tram the wheel again from the same stationary point and make a center-punch mark on the same part of the flywheel rim as before. Then find a point midway between the marks on the wheel. Now turn the engine forward until the tram just reaches from the stationary point to the central point on the flywheel rim, and the crank will be in the dead-center position for that end of the stroke. Locate the other dead center by the same method.

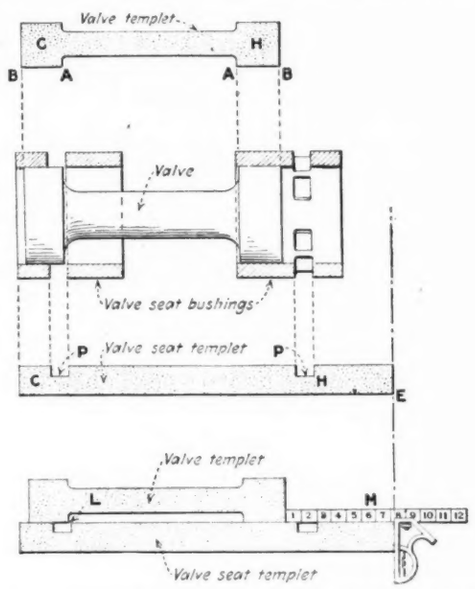


FIG. 1—TEMPLETS FOR SETTING PISTON VALVE

After the centers have been located, remove the valve from the steam chest and, as indicated at the top of Fig. 1, make an accurate templet *BB* of the valve, having head end *H* and crank end *C* with corners at *A* and *A* to represent the steam edges, and the squared ends *B* and *B* correspondingly to represent the exhaust edges of the valve. Also make a correct templet of the valve seat with notches *PP* to represent the width and distance apart of the ports, having one end *E* of the templet even with the face of the valve chamber. Mark the port notches *H* for head and *C* for crank end. The templets can be made of any light material, such as sheet tin, thin strong cardboard, or thin strips of wood with thin beveled edges.

After making the templets, place the valve back in the valve chamber, connected up and approximately located. Then place the engine on the crank end center. Block the governor in its minimum position; take a measurement from the end of the valve to the face of the valve chamber, as shown in Fig. 2, and transfer this measurement to the templets as shown at *M*, Fig. 1, when the amount of lead of the crank end can be seen and measured from the templets at *L*, Fig. 1.

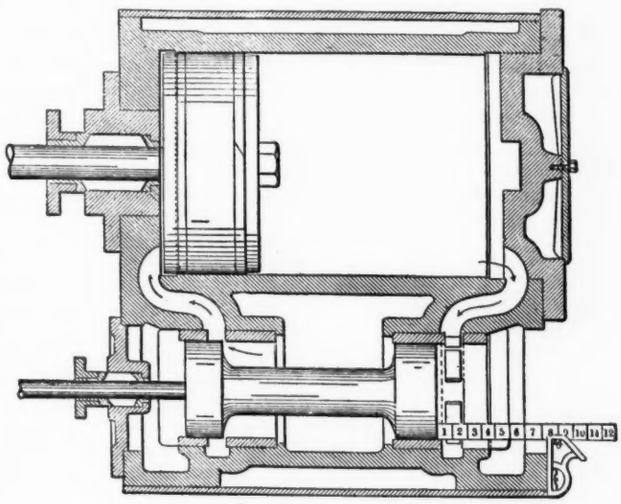


FIG. 2—MEASURING POSITION OF PISTON VALVE

If the templets when thus laid together do not show the desired amount of lead, make the necessary adjustment of the connections to the valve, allowing about ¼ in. lead for the crank end. Next turn the engine to the head end center and determine the lead in the same manner.

If necessary, readjust the valve connections and repeat the measurements and adjustment with the engine turned to alternate dead centers to obtain about one-half as much lead for the head end as for the crank end.

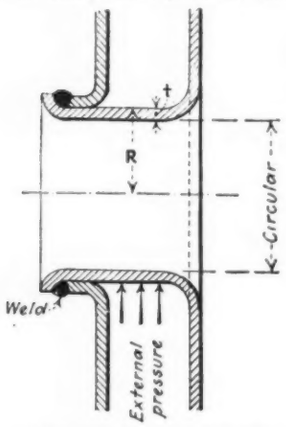
Next test the equality of cutoffs with reference to one-third stroke. Having marks on the lower guide to correspond with a mark on the lower crosshead shoe for the dead-center positions, divide the distance between them into three equal parts and place the crosshead at one-third stroke from the head end. Then block the governor so the valve is line and line at the steam edge, guided by measurements with the templets. Then turn the engine forward until cutoff occurs on the crank end. It will be noted that cutoff has occurred before the crosshead has traveled the full ⅓ stroke. Adjustment of the valve endwise will equalize the cutoffs, but will increase the difference of leads, so that this adjustment must be made to obtain the best compromise of lead and cutoffs.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Interpretations of the A.S.M.E. Boiler Code

REQUESTS for interpretations of the Boiler Code are acted upon by the Boiler Committee, their formulated replies being submitted to the Council of the American Society of Mechanical Engineers. The inquiries and replies are published from time to time in *Power*, with such explanatory comments and illustrations as seem advisable for a clear understanding of the interpretations on the part of engineers in general. The last group of interpretations published in *Power* was in the issue of May 23, 1922.

Case No. 365—Inquiry: Is it permissible, under the requirements of the Boiler Code, to weld together the outwardly projecting edges of furnace-door hole flanges by the autogenous process, provided the form of the circular door opening and the autogenous or fusion welding is as shown in Fig. 1 and the staybolting around the opening does not exceed the permissible staybolt pitch as given in Par. 199.



CASE NO. 365—PERMISSIBLE USE OF WELDING

Reply: It is the opinion of the committee that a circular door opening, of the form shown, in which the projecting cylindrical portion of the inside sheet is provided with an outwardly turned flange, at its extreme edge, to form an abutment for the edge of the circular projecting flange of the outside sheet, and is made leakproof by autogenously filling the space between these two flanges, will meet the requirements of the Boiler Code, provided the circumference of the outwardly turned flange on the cylindrical projection of the inside sheet exceeds the outer circumference of the flange of the outside sheet, and provided that the thickness of this cylindrical projection of the inside sheet conforms to the requirements of the following formula:

$$P = \frac{5000 \times t}{R}$$

where

P = maximum allowable working pressure in pounds per square inch;

t = minimum thickness of the plate forming the circular door opening in inches;

R = the radius of the outer surface of the circular door opening in inches.

Par. 199 gives the formulas for the spacing of the staybolts connecting the flat portions of the inner and outer sheets. The turning up of the extreme edge of the inner cylinder is evidently a precaution to keep the flange of the outer sheet from being pushed out over it in case the weld fails. The design appears to be such that the weld is under very little strain and serves practically no purpose beyond making the joints tight. The formula given is designed to allow a safe relation of thickness to diameter for a cylinder under external pressure.

Case No. 396—Inquiry: Is it permissible, under the requirements of Par. 257, to calk the heads of rivets? If so, how shall it be done and with what type of tools? Is it permissible to cut the plate or butt strap underneath the head and force the projecting metal up under the head?

Reply: It is the opinion of the committee that it is permissible to calk the head of a rivet, if the rivet is not loose, provided the number of rivets requiring calking is not objected to by the inspector as indicating improper workmanship. Such calking must be done with a round-nosed or other type of tool which will not score or damage the plate under the head. The plate under the head should not be cut in order to force the metal up and make the head tight.

Par. 257 reads: "The calking edges of plates, butt straps and heads shall be beveled to an angle not sharper than 70 deg. to the plane of the plates and as near thereto as practicable. Every portion of the sheared surfaces of the calking edges of plates, butt straps and heads shall be planed, milled or chipped to a depth of not less than $\frac{1}{8}$ in. Calking shall be done with a round-nosed tool."

Case No. 397—Inquiry: Was it the intent, in Par. 199, to permit a value of 175 for C where copper washers were used as described in the definition for C?

Reply: It is the opinion of the committee that the washers should be of steel to permit the use of 175 for C. Copper washers may be used provided no increase is assumed in the value of C for the strength of the washer.

According to Par. 199, the maximum allowable working pressure for various thickness of braced and stayed flat surfaces and those which by the rules require staying as flat surfaces with braces or staybolts of uniform diameter symmetrically spaced, shall be calculated by the formula,

$$P = C \times \frac{T^2}{p^2}$$

where P equals maximum allowable working pressure, lb. per sq.in., T equals thickness of plate in sixteenths of an inch; p equals maximum pitch, inches, measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined; and C is a constant whose value depends upon the thickness of the plate and the method by which the heads of the stays are brought to bear upon the plates. The smallest value of C is 112, which is for stays screwed through plates not over $\frac{7}{16}$ in. thick with ends riveted over. The highest value of C is 175, which is for stays fitted with inside and outside nuts and outside washers, and where the diameter of washers is not less than 0.4 p and thickness not less than T. The value of C is 135 for stays screwed through plates and fitted with single nuts outside of plates. According to the ruling given above, no increase could be made in this value of C if copper washers were placed beneath the nuts.

Case No. 398—Inquiry: Is it permissible under the requirements of the Boiler Code to use a single-piece dome, with the shell drawn or pressed out of one piece, eliminating the lap seam and riveting of dome head to dome shell?

Reply: It is the opinion of the committee that it was not the intent of the Code to prohibit the use of seamless construction otherwise built in accordance with the rules.

Case No. 399—Inquiry: Is it permissible, under Par. 199 of the Code, to use the value of 175 for the constant C in the formula when the outside washer is omitted and instead an inside doubler plate securely riveted to the plate is used?

Reply: It is the opinion of the committee that if three-fourths of the combined thickness of the boiler plate and doubler plate is used for the value of T in the formula, the value of 175 for C cannot be used unless outside washers are employed. It is the opinion of the committee that if the thickness of the boiler plate is used for the value of T in the formula without adding anything for the thickness of the doubler plate, the doubler plate may be considered as the equivalent of the outside washer and the value of 175 may be used for C.

This ruling will be clear if studied in the light of the comments made on case No. 397.

Case No. 400—Inquiry: Is it the intent of the Code that Par. 183, specifying the distance from centers of rivet holes to edges of plates, shall apply only to longitudinal joints, or is it applicable also to girth joints, manhole frames and other riveted attachments?

Reply: Par. 183 refers only to longitudinal joints.

Par. 183 reads: "On longitudinal joints the distance from the centers of rivet holes to the edges of the plates, except rivet holes in the ends of butt straps, shall be not less than $1\frac{1}{2}$ and not more than $1\frac{3}{4}$ times the diameter of the rivet holes; this distance to be measured from the center of the rivet holes to the calking edge of the plate before calking. The plate edge shall be beveled to an angle not sharper than 70 deg. to the plane of the plate and as near thereto as practicable."

Case No. 401—Inquiry: In Par. L-31, is it the intent that the area to be stayed is calculated from the maximum pitch squared, or the product of the actual pitches of the area supported by the stay under consideration?

Reply: The formula cited is based on the use of flat and not curved plates. In the absence of authentic data as to the reduction in stress that may be obtained due to curving the sheets, stayed curved sheets were made subject to the rules for staying flat plates. In the revision of the Code which is now under way, such allowances will be made for

stayed curved plates in conformity with rules which have been developed since the last printing of the Code. For calculating the stress in staybolts the area of surface supported can of course be used. However, for spacing of stays or estimating stresses in stayed sheets, it will not be admissible to substitute the area of surface supported for p^2.

The above refers to the locomotive code, and hence will not be discussed.

Case No. 402—Inquiry: Is it necessary, under Par. 195, where more than one manhole opening is inserted in a dished head, to increase the thickness of the head by more than $\frac{1}{8}$ in.?

Reply: It is the opinion of the committee that it is not necessary to increase the thickness of the head more than $\frac{1}{8}$ in. if more than one manhole opening is inserted, provided the mininmum distance between the manhole openings is not less than one-fourth of the outside diameter of the head.

Par. 195 requires that the thickness of a head be increased $\frac{1}{8}$ in., if it contains a manhole opening.

Case No. 403—Inquiry: Where a steam drum or dome is attached to a boiler, is this drum or dome to be considered a part of the boiler in applying the requirements of Par. 277 and 278 for the attachment of safety valves?

Reply: It is the opinion of the committee that where a steam drum or steam dome is attached to a boiler, the safety valve or valves, under ordinary conditions, may be located on this drum or dome. The area of the connection between the boiler shell and the drum or dome shall conform to the requirements in Par. 290.

Par. 277 reads: "The safety valve or valves shall be connected to the boiler independent of any other steam connection, and attached as close as possible to the boiler, without any unnecessary intervening pipe or fitting. Every safety valve shall be connected so as to stand in an upright position, with vertical spindle, when possible."

Par. 278 reads: "Each safety valve shall have full-sized direct connection to the boiler. No valve of any description shall be placed between the safety valve and the boiler, nor on the discharge pipe between the safety valve and the atmosphere. When a discharge pipe is used, it shall not be less than the full size of the valve and shall be fitted with an open drain to prevent water from lodging in the upper part of the safety valve or in the pipe.

Par. 290 requires that the area of opening of the connection shall be at least equal to the aggregate nominal area of all the safety valves to be attached thereto.

Case No. 404—Inquiry: If a dished head is formed with a flattened spot or surface for the attachment of a connection or flange, is there any limit to the size of the plane or flattened spot on the head?

Reply: It is the opinion of the committee that the diameter of the flat spot formed in the head should not exceed the value of p as given in the formula in Par. 199 or in Table 4, for the pressure and thickness of head involved.

The necesary parts of paragraph 199 are given in the discussion of case No. 397.

Case No. 405—Inquiry: If a boiler constructed to the requirements of the A.S.M.E. Code for Boilers of Locomotives, is removed from the locomotive and operated for stationary or portable service, will the rules under which the boiler was constructed still apply?

Reply: The rules for the Construction of Boilers of Locomotives do not apply to portable locomotive-type boilers, such as are used for steam shovels, steam cranes road rollers and portable boilers used for threshing grain or cutting lumber.

If a locomotive boiler is removed from the locomotive and used in stationary or portable service, it shall be treated in accordance with part I or II of the Code for Stationary Boilers.

Part I of the Code for Stationary Boilers deals with new installations and part II with existing installations.

The coal emergency is responsible for a growing demand for the classification of coal according to use. Experience in handling the distribution problem has shown the great need for information of this sort. For instance, many mines produce coal of a grade suitable for firing in locomotives, but because engine crews are accustomed to burning only one kind of coal, trouble ensues when they are requested to substitute another kind which may in reality be just as suitable. Such a classification as "locomotive coal" would do away with this difficulty.

Painting Radiators

Upon request, the American Radiator Co. has supplied *Power* with some practical information on the subject of painting radiators. As it occasionally happens that power-plant engineers are required to make decisions on this subject, it seems worth while to publish the following:

Two kinds of paint are now used on radiators—radiator enamel and radiator bronze. The enamels are made in various colors, in both flat and gloss finish, and are prepared from special formulas necessary where enamels are used on heated surfaces. Under no circumstances should ordinary paint, such as is used for wood or metal work, be applied to radiators. Within a short time after heat is turned on it will chip and flake off. Radiator bronzes give a metallic finish of high luster, the two popular shades being gold and aluminum, but the idea of attempting to give a radiator the appearance of gold or silver is gradually losing ground. The modern tendency is to paint the radiator a plain neutral color that will fit in quietly with the surroundings. In factories and office buildings one color is generally used for all radiators. If the radiators are in a factory where there is much dirt and dust, black is probably best, but where light clean work is carried on, gray or cream is frequently used. Recent experiments have shown that the form of paint used on the radiator has no great effect on its heating efficiency, so this question may be disregarded.

Before applying enamel the radiator should be thoroughly cleaned. It is particularly important that all grease or oil be removed, since enamel or primer will not adhere to an oily surface. The radiator should then be brushed clean with a stiff bristle brush. Radiators that have not been previously painted should have a coat of white primer—a special heat-resisting covering; ordinary priming paint will not prove satisfactory. The enamel should then be applied with a soft bristle brush, sometimes called a fitch brush. For the finest work two coats of primer and two coats of enamel should be used, but a satisfactory finish can be obtained from one coat of each. After applying each coat, from 24 to 36 hours should be allowed for it to dry out before applying the next.

One gallon of enamel, primer or japan will cover approximately 250 sq.ft. (one coat). When cans are opened, the contents should be stirred thoroughly before using. No attempt should be made to change the shade by adding pigments or oil. These will injure the heat-resisting quality of the paint.

Before applying bronzes, radiators should be cleaned and brushed, as for enamel. The powder should be poured in a can or saucepan and liquid added until the mixture is about the consistency of cream. The liquid should be added slowly and thoroughly stirred. Only enough should be mixed for the job, since the bronze will tarnish if allowed to stand. The same sort of brush should be used as for enamel. Care should be taken not to go over the work too much. Better luster is obtained by applying when the radiator is warm, but not hot. One pound of gold bronze will be sufficient for 300 sq.ft. of surface and one pound of aluminum for 600 sq.ft. of surface. A pound of gold powder requires about a quart of liquid, a pound of aluminum about two quarts.

Considerable interest is being shown in the Bombay district of India in the development of water power. The mountainous nature of this part of India, the need for irrigation and the heavy rainfall during the monsoon period all add to the probability of early development of hydro-electric resources. A ready market for electric power exists in the city of Bombay and vicinity, the growth of which market is being provided for by the new installation of Nila Nula, bids for which will probably be asked for in the summer of 1923. The increasing need for power in Bombay is due to the growth of mills there, to the proposed plan to electrify the steam railroads within the city and to projected new interurban trolley lines. The electrification of the steam railroads will be decided upon in the immediate future.—*Electrical World.*

Steam-Engine Valve Leakage

The weight of steam entering the cylinder of a double-acting engine per stroke is the measured steam consumption in pounds per minute divided by twice the revolutions per minute, and is known as the "cylinder feed." In engines fitted with any type of slide valve, whether Corliss, piston or the usual D type, it is found that the "indicated steam" is always less than the "cylinder feed," by an amount known as the "missing quantity."

In a discussion on this subject in *The Engineer* (London), July 21, 1922, J. E. Rycroft states that since the experiments made by Messrs. Callendar and Nicholson in 1897 on the leakage of ordinary D slide valves, there is still a point in dispute as to whether cylinder condensation or steam leakage accounted for the greater proportion of the missing quantity. Mr. Rycroft states that, although individual firms of steam-engine makers may have solved the question to their own satisfaction, so far as he is aware, no general solution has been reached and published, and in view of the important bearing of the subject on the design of steam-engine valves any further experimental evidence should be of interest.

Callendar and Nicholson's conclusions may be briefly summarized as follows:

(a) That valve leakage takes place mostly in the form of moisture rather than as a direct leakage of steam, this water being forced through the faces by the difference of pressure on the two sides of the valve, and then being evaporated on the exhaust side.

(b) Leakage was found to be approximately expressed by the law—

$$\text{Leakage in pounds per hour} = \frac{C \times \text{perimeter of valve} \times \text{pressure difference}}{\text{average overlap}}$$

and for the slide valve experimented with the constant C was found to equal 0.02.

Experiments by Professor Capper

Experiments on a slide valve by Professor Capper, at King's College, London, the results of which were published in the first report of the Steam Engine Research Committee in the main confirmed the aforementioned conclusions; but the leakage was found to be slightly greater when the valve was stationary than when it was in motion. Captain H. Riall Sankey measured the leakage past the piston valve and rings of a Willans engine, and with the usual amount of working tolerance between the valve casing and rings, found the leakage amounted to only about one-seventh of that which took place past a D slide valve, the value of the constant C being 0.003 instead of 0.02. It has been suggested that the small amount of leakage past a piston valve is to be ascribed to its simple circular shape being less susceptible to warping.

H. Denzil Lobley investigated the leakage of a piston valve, both when stationary and in motion, in a vertical jacketed cylinder, and the results were given in *The Engineer*, Feb. 9, 1912. In these experiments leakage past the top portion of the valve only was measured, and the assumption was made that the leakage past the two portions was the same. The supposed constant C was found to vary with pressure difference, but the average value was given as 0.0022.

The first series of experiments undertaken by Mr. Rycroft was directed to obtain the amount of dry or slightly superheated steam leaking past a piston drop valve 9 in. in diameter, when the pressure difference on the steam and exhaust sides of the valve was varied. The pressure difference could be arranged either by varying the inlet pressure, at the same time keeping the exhaust at constant atmospheric pressure, or by keeping the supply pressure constant and regulating the exhaust pressure by throttling the leaking steam.

The leakage was found to be uniform, so that experiments of ten minutes' duration were considered suitable, with observations taken every two minutes. Before beginning any experiment and after any variation in pressure, steam was blown through until steady conditions were obtained. The boiler supplying the steam was of the Lancashire type, 30 ft. long by 8 ft. in diameter, and was fitted with a Sugden superheater.

The steam temperatures were taken by means of a platinum resistance pyrometer placed in close proximity to the liner of the valve and coupled to a direct-reading instrument. This pyrometer was tested against a standard mercury thermometer and found to be correct for the temperatures measured. All gages were tested before and after use against a standard gage and dead weight, and the gage readings corrected accordingly. The steam in the valve casing acted as a jacket to the valve and liner, and the casing was provided with a drain cock, which was kept slightly open during the tests to get rid of any moisture.

Similar results were frequently obtained, thus showing conclusively that for this type of valve, for the range of pressure differences previously given, the leakage depends on the pressure of the entering steam and is independent of the exhaust pressure. It is obvious that if the pressures on the steam and exhaust sides of a valve were equal, no flow could take place; but the point at which the pressure difference reduces the leakage was not reached in the foregoing experiments. The results thus indicate that Callendar and Nicholson's conclusions were incorrect and that leakage is proportional to the initial pressure rather than to pressure difference.

The usual leakage constant C, when entering pressure of steam is taken instead of pressure difference, will be for a 9-in. valve,

$$C = \frac{\text{leakage in pounds per hour}}{\text{entering press. (gage)}} \times \frac{\text{mean overlap}}{\text{perimeter}}$$

$$= \frac{66.0625}{145} \times \frac{.2812 \text{ (width of ring)}}{2\ (9 \times 3.1416)}$$

$$= 0.0022.$$

This result agrees with those previously obtained for this type of valve, but supposed to be obtained on pressure difference, when in reality they were based on the entering pressure only if the exhaust pressure were constant.

Soft-Coal Peace Terms Settled at Cleveland

In the wage-scale agreement unanimously ratified at Cleveland on Aug. 15, the following provisions are made with the aim of insuring future peace in the bituminous coal industry:

1. Immediate resumption of bituminous coal mining is called for under the wage scales and working conditions, including the "check-off," in effect prior to the strike.

2. A joint conference of representatives of bituminous miners and operators is to be called Oct. 2, 1922. This conference shall appoint a commission, composed of equal numbers of representative operators and miners, to formulate a method of negotiation for a new wage agreement to become effective April 1, 1923.

3. A committee of inquiry, or "fact-finding" commission, shall be formed at the conference of Oct. 2. This committee shall conduct a thorough investigation of every phase of the coal-mining industry, throwing light on all the facts needed to effect any reorganization which the committee thinks will be of benefit to the miners, the operators and the public.

The personnel of the fact-finding committee shall be approved by President Harding, who is to appoint members if the operators and miners fail to agree on them.

4. A second conference similar to that of Oct. 2 is to be called on Jan. 3, 1923. This conference shall receive the reports of both the wage-scale committee and the committee of inquiry. It shall approve and establish, not later than Jan. 8, 1923, the wage-scale agreement which is to take effect when the present agreement expires on April 1, 1923.

Universal Craftsmen Convention

The twentieth international convention of the Universal Craftsmen Council of Engineers was held at Cleveland, Ohio, Aug. 7-11, with headquarters at the Hotel Winton. The several sessions were held in a spacious hall on the lower floor of the hotel. In the adjoining "Rainbow Room" were located the exhibits of the supply men. This room was tastefully arranged and divided into 65 booths, which were occupied by the leading firms in the power plant supply and equipment field. Many new features were displayed. The exhibition was generously patronized during the week.

On Tuesday morning the opening exercises of the convention were held. After the invocation by the Rev. E. R. Wright, the local chairman, Charles F. Siegrist, and Mrs. Henry C. Bolles, of the Ladies Auxiliary, made speeches attesting their appreciation of the large attendance and thanked the exhibitors and others who had aided in making the convention a success. James Holcomb, traction commissioner, representing the Mayor, bid the delegates and guests welcome to Cleveland. Grand Worthy Chief W. G. Warfield fittingly responded for the engineers, and Mrs. Joseph H. Nichols, president of the Ladies Auxiliary, thanked Mr. Holcomb in behalf of her organization. The ceremonies were brought to a close by an able address on "The Masonic Fraternity," by Edward Griffiths, past grand master of the State of Ohio.

There were upward of 200 delegates in attendance. The harmonious conduct of the convention made it possible to transact a large volume of important business. According to the report read by the treasurer, the organization is financially strong. During the year three new councils have been instituted, and there has been a net gain of about 600 in membership, with bright prospects for greater gains during the coming fall and winter.

On Tuesday evening there was a stag smoker and on Thursday a vaudeville performance, the two events being well attended. The real entertainment feature, however, was the picnic at the summer home of Past Grand Worthy Chief Charles F. Siegrist. Automobiles conveyed the conventionites to the beautiful grounds surrounding the home of the Seagrist family, bordering on Lake Erie, where a hearty welcome awaited them.

On Friday morning memorial services were held for members who had passed away during the year.

Fully three hundred delegates and guests were seated at the banquet tables in the main ball room on Friday evening. The newly-elected Grand Worthy Chief James M. Patton briefly addressed the diners, and then an evening of dancing brought the convention to a close.

The convention committee comprised: Charles F. Siegrist, chairman; Ernest H. Smith, secretary; William Fritz, treasurer; Henry Bolles, P. J. Shomer, A. Lovejoy, Daniel Conway, John Vickers, Edward Smith and O. N. Pomeroy.

The grand officers elected for the ensuing year are: W. G. Warfield, past chief, Newark, N. J.; James M. Patton, chief, Buffalo, N. Y.; G. G. Brown, assistant chief, Pittsburgh, Pa.; Thomas H. Jones, secretary, Washington, D. C.; John L. O'Brien, treasurer, Chicago, Ill.; W. W. Law, warden, Princeton, N. J.; Walter H. Damon, guard, Springfield, Mass.; John MacMorran, chaplain, Newark, N. J. The trustees included L. J. Cudbird, Toronto, Canada; Charles Clarke, Cleveland, Ohio; and John Hass, Chicago, Ill.

Rochester, N. Y., was selected as the convention city for 1923.

UNIVERSAL CRAFTSMEN AND GUESTS AT THE PICNIC ON THE SHORE OF LAKE ERIE

The lower view is a continuation of the upper.

News in the Field of Power

Federal Power Engineer Tours Northwest

Throughout the entire inter-mountain region of the Northwest there is evidence of intelligent efforts to utilize large amounts of the potential water power available in that section. This is the observation of Major Howard S. Bennion, assistant chief engineer of the Federal Power Commission, who has just returned from an inspection trip in the Northwest.

Since hydro-electric power must be developed in large blocks to be profitable, Major Bennion states that the preliminary investigations must be necessarily slow and painstaking. He believes that the greatest immediate promise for the use of hydro-electric power in this region lies in the electrification of sections of the trans-continental railroads. Electrification of railroads is a use of hydro-electric power that almost invariably leads to further expansion, since when one section of a road is electrified there is always a tendency to add to the mileage over which electrification extends.

With regard to conditions in the individual Northwestern States, Major Bennion believes that additional water power must be developed soon in Utah and Oregon, if the rapidly growing market in those states is to be kept supplied. In Idaho, the opposite condition prevails—a larger market is needed to take care of the present supply of power. Increased activities in the copper industry in Montana have caused a revival of the power market there, although the existing installations at Butte and Great Falls will be adequate for some time to come.

Short Course in Refrigeration Engineering

Because of numerous requests for instruction that would give in a practical manner, and in the shortest possible time, a thorough knowledge of the theory and practice of refrigeration engineering, the Siebel Institute of Technology, Chicago, will open on September 12 a special three-months course in that subject.

The three-months course will, it is announced, deal only with the most essential subjects in the field of refrigeration engineering; therefore, it will be of the greatest value to those who have had at least the rudiments of an engineering education. Of particular value to the students will be the limited size of the classes, which will make it possible for instructors to give individual attention to each class member.

Further particulars may be had by addressing the Refrigeration Division, Siebel Institute of Technology, 958-62 Montana St. Chicago, Ill.

Lakeside Power Plant Adds New Equipment

A 30,000-kw. generator is being installed in the Lakeside plant of the Milwaukee Electric Railway & Light Co. described in *Power* for April 18, 1922, as the largest power station in the United States using pulverized fuel. This addition to the equipment of the Lakeside station will increase the capacity of the plant 75 per cent, since there are now two 20,000-kw. generators in operation. The sum of $1,250,000 is being spent on the new installation, and next year about $1,000,000 will be spent on additional boiler capacity.

Iron and Steel Convention To Discuss Power Problems

The Iron and Steel Exposition and Convention of the Association of Iron and Steel Electrical Engineers, to be held in Cleveland, Sept. 11-15, will be marked by the presentation of a number of papers relating to the application of power in the iron, steel and allied industries.

Among the more important of such papers are the following: "Improvements in Efficiency of Electric Power Supply," by Dr. Charles P. Steinmetz, chief consulting engineer, General Electric Co., Schenectady, N. Y.; "A Review of Steel Mill Electrification," by B. G. Lamme, chief consulting engineer, Westinghouse Co., East Pittsburgh, Pa., and Wilfred Sykes, assistant to operating vice-president, Steel & Tube Co. of America, Chicago, Ill.; "Judging Combustion from Gas Analysis," by A. G. Witting, assistant chief engineer, Illinois Steel Co., Gary, Ind.; "The Gas Engine as a Prime Mover for Power Generation," by D. M. Petty, electrical superintendent, Lehigh Plant, Bethlehem Steel Co., South Bethlehem, Pa.; "Steam Turbines," by L. W. Heller, general superintendent of power stations, Duquesne Light Co., Pittsburgh, Pa.; "Power in the Iron and Steel Industry," D. B. Rushmore, consulting engineer, General Electric Co., Schenectady, N. Y.; "Education," by L. F. Galbraith, electrical superintendent, West Penn Steel Co., Brackenridge, Pa.; and "Electrical Developments in 1922," by R. B. Gerhardt, electrical superintendent, Bethlehem Steel Co., Sparrows Point, Md.

In addition there will be a topical discussion on "Boiler Practices of 1922," to be participated in by the following men: J. B. Crane, combustion engineer, George T. Ladd Co.; E. R. Fish, vice-president, Heine Boiler Co.; R. M. Rush, Springfield Boiler Co.; R. E. Butler, Babcock & Wilcox Co.; F. Hodson, Electric Furnace Construction Co.; Prof. Edgar Kidwell, general manager, Kidwell Boiler Engineering Co.

British Coal Exports to United States Limited

In looking after the temporary needs of the American coal market, Great Britain is not likely to neglect its regular export trade. The National Merchant Marine Association believes that exports from England to the United States will not exceed 1,000,000 tons a month. It is expected that practically half of that amount will be carried in American vessels, large numbers of idle vessels in the United States Shipping Board Fleet having been chartered for this purpose. During its study of the situation the Merchant Marine Association found that the absolute limit of total British coal export at this time is 2,000,000 tons a month. During the war a greater capacity was reached, but much of England's coal handling machinery at tidewater is no longer serviceable.

Open Washington Office To Handle Coal Situation

The National Electric Light Association, the American Gas Association and the American Electric Railway Association have opened a joint office at 949 Munsey Bldg., Washington, for the purpose of co-operating with federal officials with regard to fuel for public utilities. Final arrangements for the Washington office were made by M. H. Aylesworth, of the National Electric Light Association, and A. I. Phillips, of the American Gas Association, after a conference on the public-utilities fuel situation with Secretary Hoover, Federal Fuel Distributor Spencer, and other federal officials.

To Standardize Steam Tables

Interest of mechanical engineers has lately been directed to the improvement of steam tables as to both accuracy and extension of range, to keep pace with modern steam-turbine practice. Through the agency of the American Society of Mechanical Engineers, the co-operation of the Bureau of Standards with several other institutions has been sought in a program of investigation leading to new data for the formulation of steam tables adequate to present needs.

The problem suggested as the appropriate initial work for the Bureau of Standards was the measurement of the specific heat capacity of water. Two phases of this problem are presented. First, data on the specific heat capacity of water from 0 deg. to 100 deg. C. in terms of international units of energy are wanted to establish the fundamental heat unit to a better degree of certainty than is known at present. Second, data are wanted on the heat capacity of water from 100 deg. C. to as much higher a degree as is practicable,

together with precise information on other properties of steam, as a further basis of steam-table construction.

The design of a calorimeter for this investigation is now in progress. Because of the special nature of the problem much of the construction is tentative until its suitability is confirmed by experiment. Several features of the design involving novelty have already been the subjects of experiment, and others are being constructed.

No useful object would be served by hastily conceived measurements carried out in crudely designed and roughly constructed apparatus. Only by strict attention to detail and patience in its thorough execution can calorimetric data of unquestionable reliability be obtained. This is one of the object lessons of the previous investigations of ammonia. For this reason no definite time can be set for completion of the work. Those in charge state, however, that it must be a matter of years, not months, if any real contribution is to be made.

Recent Water-power Applications

The Nevada Irrigation District, Grass Valley, Calif., has applied to the Federal Power Commission for a preliminary permit to cover an irrigation and power project on the middle fork of the Yuba River and on Canyon Creek on the south fork of the North Yuba and on the north fork of the Middle Yuba. The primary power available is estimated at 45,000 h.p.

P. B. Cross, Mills Building, San Francisco, has applied for a preliminary permit covering a power project on Deer Creek near Chico, Calif. The project involves the construction of a dam on Deer Creek with a tunnel and conduit twelve miles long connecting with a power house on the same stream. The primary power is estimated at 9,500 hp. The applicant indicates his intention, however, to install equipment capable of generating 20,000 hp.

The Washington Coast Utilities Co., Arlington, Wash., has applied for a license covering a transmission line which will cross certain public lands near Waterville, Washington.

The San Diego (Calif.) Consolidated Gas and Electric Co., has applied for a license covering a transmission line to connect the Rincon Indian Reservation and the Henshaw Dam.

Detroit Edison To Add New Plant

A new station of 60,000 kw. initial capacity on Slocum's Island is being planned by the Detroit Edison Co. Preliminary plans and engineering work have been completed, but construction will probably be postponed until 1923. The new station will be of the same size as the recently constructed Marysville plant of the Detroit Edison Co. and will assist the Delray plant in serving the down-river districts, as well as supplying sections of west and northwest Detroit with power. The cost of the new plant is estimated at $10,000,000.

Engineers of Rhode Island Unite

According to Prof. James A. Hall, president of the Providence Engineering Society, "Practically all Rhode Island engineers are enthusiastically united in one organization made up of a large local society and affiliated sections of national engineering societies—an organization which is giving a real service to its members and to the industries of the state."

Six years ago the Providence Engineering Society was formed as a result of expansion of the existing mechanical engineering association to include all kinds of engineering. Continued growth resulted in the establishment of a number of professional sections including Machine Shop, Power, Management, Public Works, Structural, Textile and Design. Co-operation of these specialized sections with corresponding locals of the A.S.M.E., A.S.C.E. and A.I.E.E. came as a matter of course, since the leaders of each local were likewise associated with the Providence Engineering Society.

This co-operation has worked to the advantage of all concerned. The national society sections hold meetings jointly with the corresponding groups of the Providence Society, which in turn gives free use of its rooms, projector, etc. Better attendance and less expense result from this arrangement. The Providence Society, on the other hand, benefits through having more and better meetings, and has a greater influence in public affairs, in proport on to its increased activity.

Coming Conventions

National Safety Council, 168 N. Michigan Ave., Chicago, Ill. Eleventh Annual Safety Congress, Detroit. Aug. 28-Sept. 1.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Des Moines, Ia., Sept. 11-16. Annual conventions and exhibitions of the State Associations scheduled as follows:

Iowa, at Des Moines, Sept. 10-11; Abner Davis, Room 16, Waterhouse Block, Cedar Rapids, Iowa.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention and exhibition at Minneapolis, Minn., Sept. 11.

Association of Iron and Steel Electrical Engineers, 1007 Empire Bldg., Pittsburgh, Pa. Annual convention and exhibition at Cleveland, Ohio, Sept. 11-16.

New England Water Works Association, Boston. Annual convention at New Bedford, Mass., Sept. 12-15.

May Adopt A.S.H. & V.E. Ventilation Code as Standard

The heating and ventilation code of the American Society of Heating and Ventilating Engineers has been submitted to the American Engineering Standards Committee for approval as the American Standard.

This code was prepared in 1915 in response to requests from state commissions, legislative bodies and public health agencies for suggestions to be used in the preparation of legislation pertaining to the heating and ventilation of public and semi-public buildings. The first section of the code relates to general matters pertaining to all classes of building; the remaining three sections relate to schools and colleges, factories and theaters, respectively.

The American Engineering Standards Committee has appointed a special subcommittee to investigate the status of the code in the industry and the desirability of approving it. Sidney J. Williams, chief engineer of the National Safety Council, is chairman.

Certain states, among them being Illinois, Indiana, Kansas, Massachusetts, Minnesota, New Jersey, New York, Ohio, Pennsylvania, Utah, Virginia and Wisconsin, have already used parts of the code in drafting their laws relative to heating and ventilation.

New Association To Study Human Factor in Industry

"To advance the understanding of the principles, policies and methods of creating and maintaining satisfactory human relations within commerce and industry," an organization known as the National Personnel Association has been formed. It is made up of leaders of organized engineering, representatives of large industries, insurance companies, railroads and publishers, and members of university faculties. Taking over the activities of the National Association of Corporation Training and the Industrial Relations Association of America, the new organization will aid business executives in solving problems of personnel administration. A form of co-operative research will be conducted on a nation-wide scale, and close relations will be established with colleges and universities in carrying out an extensive educational program.

C. S. Coler, educational director of the Westinghouse company, has been appointed chairman of a committee on industrial and public school relations. W. E. Wickenden, assistant vice-president of the American Telephone and Telegraph Co., heads the committee on relations with engineering schools. A third committee will consider relations with collegiate schools of business. During the remaining months of 1922 fifteen other committees will report on national, economic and industrial problems.

With regard to the proposed co-operation with educational institutions, the following statement was made: "The Association recognizes that industry and commerce need a better understanding of what our educational institutions are undertaking and how they are functioning, and it recognizes that educational institutions desire to secure a better understanding of the personnel needs of commerce and industry. It, therefore, plans to maintain reciprocal relations with educational institutions and in carrying out this purpose has appointed the three above-named educational committees."

New Obstacle to Water-Power Development

An interpretation of the water-power law made by Attorney-General Daugherty will, it is believed, render the preliminary water-power permit practically valueless. In the opinion of the Attorney-General conditions may be inserted in the license which were not indicated in the preliminary permit, and a license may be refused even if the permittee has complied with all the provisions laid down in the preliminary permit.

The preliminary investigation necessary in establishing water-power sites frequently involves large expenditures, and it is believed that the Attorney-General's interpretation of the law will do much to discourage such expenditures, and will consequently lay a further obstacle in the path of water-power development. It is the general belief that the Attorney-General's opinion does not represent the original intent of the law and that steps will be taken at once to amend the act so that applicants for water-power licenses will in future find the preliminary permit sufficiently binding to justify their incurring the expenses necessary for the proper preliminary investigations.

As an immediate result of the Attorney-General's opinion the Federal Power Commission is relieved, for the present, from any obligation to issue a license on the Girand application covering a power site at Diamond Creek on the Colorado River.

A special form to be used by the state governors in the distribution of coal has been issued by Federal Fuel Distributor Spencer, with the object of providing uniformity of method in coal handling during the present shortage. The form calls for the name of the applicant; the point at which the shipment is to be delivered; the name of the delivering railroad; the purpose for which the coal is to be used; the quantity, grade and size of coal; the consignee's average daily consumption; the consignee's present stock; the name of the firm with which the applicant has a contract; the district from which coal ordinarily is supplied, and the name of the bank which will guarantee payment when the coal is shipped.

New Publications

The Marine Power Plant. By Lawrence B. Chapman, Professor of Naval Architecture at Lehigh University. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. Cloth; 6x9 in.; 320 pages; 113 illustrations. Price, $4.

This book was designed especially to meet the needs of students of naval architecture. After a short introduction in review of the subjects of thermodynamics and fuels, it proceeds to give the main facts in regard to the various types of power-generating apparatus used on shipboard. Most space is given to the design and handling of various types of marine boilers, but there is a fair amount of material on reciprocating steam engines, steam turbines, Diesel engines, condensers, etc. The volume ends with a complete set of computations for the power plant of a small steamship.

Railway Electric Traction. By F. W. Carter, Rugby, England. Published by Longmans, Green & Co., Fourth Ave. at Thirtieth St., New York City. Cloth; 5½ x 8½ in.; 412 pages. Price, $8.50 net.

An exhaustive treatise on the tractive features of railway electrification, giving methods of calculation and discussion of current practice in design. Descriptive matter is regarded as being outside the scope of the book, and is consequently used only where illustration of the theory is needed.

Obituary

Frank H. Yeager, a well-known member of the Ohio, No. 36, N. A. S. E., and a member of the Ohio Board of Boiler Rules, passed away on June 4. Mr. Yeager was president of the Ohio State Association, N. A. S. E., for two terms, and was president of his own chapter for two years. He was chairman of the legislative committee when the State boiler inspection laws were enacted.

Charles B. Norman, for forty years manager of the export department of the Tide Water Oil Co., and past president of the Maritime Association of the Port of New York, died at the summer home of his son, George S. Norman, Sayville, L. I., on Aug. 13. Mr. Norman was 71 years of age. The interment was at Laurel Hill Cemetery, Philadelphia, Pa.

Frank Eardley, for twenty years manager of the St. Louis office of the Dearborn Chemical Co., succumbed on July 6 to a sudden attack of heart disease, brought on by a plunge in the swimming pool of the Missouri Athletic Club. Mr. Eardley died at the age of 57, after several months of ill health. He was an active member of several Masonic organizations in Missouri, and was also a past president of the St. Louis Association of Stationary Engineers No. 2, Missouri, N.A.S.E., and a member of the Universal Craftsman Council of Engineers No. 25.

Charles Gray Cooper, for 45 years identified with the C. & G. Cooper Co., engine builders, Mt. Vernon, Ohio, died at his home in Mt. Vernon on Aug. 4. Mr. Cooper was born in Mt. Vernon on Dec. 11, 1845, and was the son of Elias Cooper, one of the founders of the C. & G. Cooper Co.

Mr. Cooper became connected with the Cooper Co. in 1866, at which time it was a partnership. He became secretary of the company in 1898, when it was incorporated, and served in this capacity until the death of the president, F. L. Fairchild, in 1912, when he was made president. He served as president until his illness in 1918, when B. B. Williams was made president and Mr. Cooper became chairman of the Board of Directors, which, as an honorary title, he held until his death.

Mr. Cooper was one of the pioneer engine builders of this country, and practically his entire life was spent in the development and building of Cooper steam and gas engines.

Personals

W. L. Ticer, formerly mechanical engineer in the municipal architect's office, Washington, D. C., is now superintendent of mechanical division for A. B. Clark, a contractor of that city.

E. W. Rossiter has been appointed engineer of construction for Freyn, Brassert & Co., Chicago. Mr. Rossiter was previously chief engineer of the Interstate Iron & Steel Co., Calumet River, Chicago.

Dr. A. E. Kennelly, professor of electrical engineering at Harvard University and the Massachusetts Institute of Technology, has been awarded the cross of the Legion of Honor for distinguished service as exchange professor in engineering to the French Republic.

Business Items

The Wisconsin Electric Co., Racine, Wis., has appointed E. S. McGonegal as its resident sales representative in metropolitan New York and northern New Jersey, with headquarters at 27 Warren St., New York City.

The National Carbon Co. Inc., Cleveland, Ohio, has established two finishing plants, one located at 337 East 41st St., New York City, and the other at 560 West Congress St., Chicago, to supplement the emergency department maintained at the Cleveland factory.

The Schaeffer & Budenberg Manufacturing Co., of Brooklyn, N. Y., and the American Steam Gage and Valve Co., of Boston, were consolidated on Aug. 1. G. A. Binz has been appointed sales manager of the consolidated firm, with offices at Berry and South Fifth Sts., Brooklyn, N. Y.

The Moore Steam Turbine Corp. has recently opened its own offices as follows: New York, domestic, 50 Church St., S. G. Peticolas, manager; New York, export, 50 Church St., Maximilian Avilés, manager; Chicago, 10 South La Salle St., S. S. Wilson, manager. Additional offices of the corporation are located in 25 other cities in the United States.

The Conveyors Corporation of America, 326 W. Madison St., Chicago, Ill., has appointed the newly organized Florandin Equipment Co. as its representative in the New York territory. The new organization, with offices at 110 W. 40th St., New York City, will handle the American Steam Jet Ash Conveyor and the American Trolley Carrier, taking care of erection and installation.

Trade Catalogs

Insulating Compounds—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. A sixteen-page bulletin describing the various insulating and soldering compounds, varnishes, shellacs, paints, cements, glues and switch oils, made by the Westinghouse Co.

Powdered Coal Equipment—Quigley Fuel Systems, Inc., 26 Cortlandt St., New York, N. Y. A four-page bulletin which illustrates and describes the component parts of the company's appliances for preparing, distributing and burning powdered coal. The dust-tight features of the apparatus are especially emphasized. A series of drawings in elevation shows clearly the progress of the powdered coal through a typical plant, from track hopper to furnace.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Aug. 7, 1922	Aug. 14, 1922
Pool 1,	New York	.....	.....
Smokeless,	Columbus	$3.50–7.00	$3.50–8.00
Clearfield,	Boston	6.25–7.50	7.00–9.00
Somerset,	Boston	6.25–7.50	7.75–9.00
Kanawha,	Columbus	3.50–7.50	3.50–7.50
Hocking,	Columbus	3.50–7.50	3.50–8.00
Pittsburgh No. 8	Cleveland	7.75–8.00	7.00–7.50
Franklin, Ill.,	Chicago	.....	.....
Central, Ill.,	Chicago	.....	.....
Ind. 4th Vein,	Chicago	.....	.....
West Ky.,	Louisville	3.50–9.00	3.50–9.00
Big Seam,	Birmingham	2.20–4.25	2.20–5.50
S. E. Ky.,	Louisville	3.50–8.00	3.50–8.00

FUEL OIL

New York—Aug. 17, Port Arthur light oil 22@25 deg. Baumé 4c. per gal.; 30@35 deg., 5c. per gal. f.o.b. Bayonne, N. J.

Chicago—Aug. 7, for 24@26 deg. Baumé, $1.15 per bbl.; 21@36 deg., 3½c. per gal. in tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Aug. 14, f.o.b. refinery, Pennsylvania, 36@40 deg., 5¾c.; Kentucky fuel oil, 26@30 deg., 4c. per gal.; Gas oil, 32@34 deg., 2¾c. per gal.; 36@38 deg., 3c.; 38@40 deg. 3¼c. Western, 24@30 deg., $1.05@$1.10 per bbl.

Philadelphia—Aug. 14, 26@28 deg. Baumé, Oklahoma, $1.10@1.15 per bbl.; 30@34 deg., Oklahoma (group 3), 2¾@3c. per gal.; 18@20 deg. Seaboard, $1.40@$1.50 per bbl.

Cincinnati—Aug. 8, for 26@28 deg. Baumé, 5½c.; Diesel, 28@30 deg. 5½c. per gal.; distillate 38@40 deg., 6c.

Cleveland—Aug. 8, 26@28 deg. Baumé, 4½c. per gal.

New Plant Construction

PROPOSED WORK

Cal., Berkeley—The University of California received bids for a 2 story, 70 x 186 ft. building, to be known as Haviland Hall, from R. Trost, 26th and Howard Sts., $337,016; K. E. Parker, 519 California St., $337,400; I. M. Sommer Co., Balboa Bldg., $338,428; contractors all of San Francisco.

Cal., Palo Alto—The U. S. Government received bids for rehabilitation of water system here, including moving and resetting certain pumping equipment, pipe line, and other machinery, from Turner Co., 273 Natoma St., San Francisco, $34,595; M. Murphy, 1321 Milvia St., Berkeley, $37,700; C. M. Krause, $38,350.

Cal., San Francisco—The Bd. Pub. Wks. will receive bids until Sept. 6 for furnishing and delivering street car motor and air-brake equipment for Municipal Rys. under Contract 132, Sects. C and D. Noted Aug. 15.

Cal., San Francisco—Bids were opened by Bd. Pub. Wks., Aug. 9, for furnishing and delivering transformers, switchboards and accessory equipment for Moccasin Creek power plant, Hetch Hetchy project, Contr. No. 81, (a) bidding No. 2 proposition A, (b) bidding No. 1 proposition A, (c) bidding proposition E, (d) bidding proposition A1, No. 1 and No. 2 (e) bidding proposition E1, from Maloney Electric Co., Rialto Bldg., (a) $6,578; Packard Electric Co., (A. S. Lindstrom), 111 New Montgomery St., (a) $7,140; General Electric Co., Rialto Bldg., (a) $7,941 (b) $13,429 (c) $265,000, (d) $13,105 and $7,657, (e) $253,600; Westinghouse Electric & Mfg. Co., Natl. Bank Bldg., (a) $7,485 (b) $11,069 (d) $10,300 and $7,485; C. F. Henderson, Call Bldg., (a) $7,090. Noted July 18.

Cal., Turlock — The Turlock Irrigation Dist. received bids for constructing transmission line, (a) construction complete, (b) labor only, (c) equipment only, from H. S. Tittle, 766 Folsom St., (a) copper wire, $153,360, aluminum wire, $142,360, (b) $31,000; W. A. Kraner, Balboa Bldg., (a) copper wire, $169,900, aluminum wire, $178,200; P. C. Severin, 180 Jessie St., (b) $46,800; Continental Constr. Co., (b) $67,000; Western Electric Co., 680 Folsom St., (c) towers, $280 each; General Electric Co., Rialto Bldg., (c) switchboards, $18,250; J. Roebling Sons, Hawthorne and Folsom Sts., (c) copper wire, $.17¾ per lb.; Aluminum Co. of America, Rialto Bldg., (c) aluminum wire, $.1904 per lb.; Baker-Joslyn Co., 199 First St., (c) insulators, $1.87 each, alternate, $2.53 each; Latt Insular Co., (c) insulators, $2.25 each; Pacific States Electric Co., 575 Mission St., (c) insulators, $2.30 each, copper wire, $.1662 per lb.; Ohio Brass Co., Hobart Bldg., (c) insulators, $2.35 each; Pacific Coast Steel Co., Rialto Bldg., (c) towers, $110 each; Westinghouse Electric Co., Rialto Bldg., (c) insulators, $2.47 each. Contractors all of San Francisco. Noted July 25.

Fla., Apalachicola—The city, F. B. Wakefield, Clk., will receive bids until Sept. 12 for furnishing and installing power and generator equipment for a 2 unit, 200 kw. electric light and power plant, to be operated in combination with a municipal water plant; power to consist of one 100 hp. and one 150 hp. engines directly connected to generators.

Ill., Evanston—W. S. Holmes, Archt., Tussing Bldg., Lansing, will receive bids in the spring of 1923 for a 3 story kindergarten college, including 4 story auditorium, for E. Baker. Estimated cost $750,000.

Ind., Evansville—The Bd. Educ. is having revised plans prepared for a 2 story, 250 x 300 ft. high school. Estimated cost $400,000. J. C. Llewellyn, 38 South Dearborn St., Chicago, Archt.

Ia., Oskaloosa—The city is having plans prepared for a dam 800 ft. long, 10 ft. head, 2,400 hp. Estimated cost $270,00. Fargo Eng. Co., West Cortland St., Jackson, Mich., Engrs., Burns & McDonell, Interstate Bldg., Kansas City, Mo., Assoc. Engrs.

La., New Orleans—The Sewerage & Water Bd., A. G. Moffat, Secy., will receive bids until Oct. 10 for furnishing one 6,000 kw. steam turbine and accessories.

La., Shreveport—The city has authorized a bond issue of $4,000,000 for the construction of a new courthouse and jail, also storm sewers, street paving and fire alarm system.

La., Shreveport—The city voted $1,000,000 bonds and plans to build a new high school and 7 grammar schools. Architect not selected.

Mich., Battle Creek—The Rich Steel Products Co., Springfield Pl., plans to build a 3 or 4 story factory next year. Estimated cost $500,000. Architect not selected.

Mich., Battle Creek—The U. S. War Veterans Bureau, Col. C. R. Forbes, Dir., Navy Dept., Wash., D. C., is having plans prepared for a 2 and 3 story hospital at Camp Custer. Estimated cost $1,500,000. Private plans. Location formerly reported as Great Lakes, Ill.

Mich., Kalamazoo—R. A. Leroy, Archt., Pratt Bldg., will receive bids until Sept. 15 for a 4 story addition to high school for the Bd. of Educ. Estimated cost $430,000.

Mich., North Branch—The village, C. B. Farnsworth, Clk., plans waterworks improvements, consisting of a tank and tower for storage supply, including pumping machinery, also excavating and laying approximately 15,000 ft. of 4 and 6 in. c.i. mains and setting hydrants.

Miss., Pelahatchee—The city plans to install waterworks and electric light systems. Estimated cost $40,000. Swanson-McGraw, Inc., 705 United Fruit Bldg., New Orleans, Consult. Engrs.

Miss., Utica—The city plans to install an electric lighting system. Estimated cost $15,000. Swanson-McGraw, Inc., 705 United Fruit Bldg., New Orleans, Consult. Engrs.

Mo., Kansas City—Brostrom & Droths, Archts., 310 Reliance Bldg., will receive bids until about Sept. 10 for an 11 story, 48 x 126 ft. hotel at 911 Holmes St. for C. O. Jones, 308 Commercial Bldg. Estimated cost $400,000.

Mo., Kansas City.— The Washington Theatre Building Co., G. M. Mack, Mgr., will soon receive bids for a theatre on Paseo Parade. Estimated cost $350,000. V. DeFoe, 720 Scarritt Bldg., Archt.

N. J., Wildwood—W. Lipkin, Land Title Bldg., Phila., plans to build a 6 story, 200 x 800 ft hotel on 23rd St. and Boardwalk. Estimated cost $1,000,000. Architect not selected.

N. Y., Angelica—The village has voted $20,000 bonds and plans to build an electric lighting plant, including a 3 mile transmission line to connect with the Genesee Valley Electric Light & Power Company's system at Transit Bridge. Engineer not announced.

N. Y., Long Island City—The Nat'l Liquid Bleach Co., 18 Purvis St., plans to build a factory on Foster Ave. Estimated cost $500,000.

N. Y., Maspeth—The Bd. Educ. received bids installing heating, ventilating, and temperature regulating apparatus in addition to and alterations in (a) P. S. 72, Maspeth Ave. and Hill St., (b) P. S. 58, East 176th St., and Washington Ave., from E. Rutzler Co., 404 East 49th St., (a) $48,462, (b) $44,719; W. J. Olvany, 100 Charles St., (a) $51,402 (b) $46,830; T. F. Hall, Inc., 405 Lexington Ave., (a) $52,000 (b) $47,000 contractors all of New York.

N. Y., New York—The Bd. Educ., 500 Park Ave., received lowest three bids for P. S. 65 on East 141st St., Bronx Boro, from E. Deibitsch, Inc., 70 East 45th St., $609,000; Frymier & Hanna, 25 West 45th St., $611,450; T. A. Clarke Co., 122 Livingston St., Brooklyn, $617,000.

N. C., Concord—A. B. Pounds is in the market for an electrically operated 25 ton, ice machine and equipment for ice manufacturing plant.

Ohio, Cleveland—The city, c/o G. Beckwith, 204 City Hall, is in the market for a 1402 hp. type Q. economizer, capacity 84,000 lbs. per hour, at 250 lbs. working pressure, with forced and induced draft fans.

Pa., Altoona—The Diocese of Altoona, c/o J. J. McCort, plans to build a 1 story cathedral on 13th St. Estimated cost $500,000. G. I. Lovatt, 416 Walnut St., Phila., Archt.

Pa., Castanea—The Lock Haven Electric Light & Power Co. plans to build a power house. Estimated cost $200,000. Engineer not announced.

Pa., Chester—The Cambridge Trust Co. plans to build a new bank and office building on 5th and Market Sts. Estimated cost $500,000. Engineer not announced.

Pa., Erie—The School District, R. S. Scobell, Secy., will receive bids until Aug. 28 for a 2 story, 167 x 303 ft. school to be known as Theodore Roosevelt School, including steam heating system. Estimated cost $450,000. Mayer, Valentine & Cameron, Erie Bldg., Cleveland, Ohio, Engrs. W. W. Meyer, Erie, Archt.

Pa., Hazelton—C. D. Markle, Jr., plans to build a 10 story fireproof hotel. Estimated cost $500,000. Heating and ventilating systems will be installed.

Pa., Newcastle—Williams Electric Service, 217 East North St., is in the market for small motors.

Pa., Pittsburgh—J. R. McNary, 435 6th Ave., is organizing the Neville Twp. and the Kennedy Twp. Light Companies and plans to install and operate electric light and power plants in these two townships.

Pa., Scranton—Bd. of Control, J. H. Williams, Pres., 425 Washington Ave., plans to build a power house in connection with institution buildings, on Adams Ave. and Gibson St., and is in the market for equipment. Estimated cost $61,000. Engineer not announced.

S. D., Platte—The city will receive bids until Sept. 5 for 2 semi-diesel 15 hp. engines, with regular equipment.

Tenn., Nashville—The Scottish Rite Consistory, 7th Ave., will soon receive bids for a temple. Estimated cost $500,000. Asmus & Clark, Stahlman Bldg., Archts.

Va., Richmond—The Richmond, Fredericksburg & Potomac R.R. Co. is having plans prepared and will receive bids about Sept. 1 for a coal tipple at the Acca Yards. Estimated cost $300,000. Private plans.

Wash., Everett—The City has purchased a 21 acre site and plans to build a 3 unit reservoir, one unit to be built at this time; proposed storage dam will have capacity of 20,000,000 gallons. A. B. Cutter, Everett, Engr.

W. Va., Charleston—The Kanawha Investment Co. is having plans prepared for an 8 story, 200 x 200 ft. store and office building. Estimated cost $450,000. Mills-Millspaugh & Carmichael, 67 East Long St., Columbus, Ohio, Archts. Noted Aug. 1.

Wis., Kenosha—The School Bd., F. J. Drissell, Chn. Bldg. Comn., 921 Charles St., is having preliminary plans prepared for a 3 story elementary school. Estimated cost $300,000. J. D. Chubb, 109 North Dearborn St., Chicago, Archt.

Wis., Milwaukee—The Seaman Body Corp., 1732 Richard St., is receiving bids for a 5 story, 100 x 225 ft. and 123 x 420 ft. factory for the manufacture of automobile bodies. Private plans.

Ont., Brantford—A syndicate (Ald Ballantyne, head) plans to build an arena and wants prices and information on an artificial ice plant. Estimated cost $100,000.

Ont., Delaware—The Twp. of Caradoc, J. Brodie, Secy., Muncey, plans to install an electric light and power distribution system from here to Melbourne, a distance of 10 mi. Estimated cost $20,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

Ont., Hamilton—The Libbey Owens Sheet Glass Co., H. Allen, Mgr., plans to extend its factory and will install additional equipment. Estimated cost $250,000. Private plans.

Ont., London—The Western University will soon award the contracts for a science building and an arts building. Estimated cost $250,000 each. J. M. Moore, 489 Richmond St., Archt. Prices wanted on all materials and equipment, including 4 boilers and complete radiation central heating plant. Noted Mar. 7.

Ont., St. Thomas—The School Bd., R. Kilmer, Chn., will receive bids until Sept. 16 for 2 story additions to schools on Myrtle and Balaclava Sts. Estimated cost $150,000. N. R. Darrach, 430 Talbot St., Archt. Steam boilers and radiation, plumbing and ventilating systems will be installed in same.

Ont., Toronto — Trinity College, Queen St., W., will soon award the contract for a 3 story college on Hoskin Ave. Estimated cost $500,000. Darling & Pearson, 2 Leader Lane, Archts.

Que., Quebec—The Quebec Running Comn., Parliament Bldgs., had plans prepared and will soon receive bids for 2 dams, about 1,000 ft. long, each, on Kenogami Lake, for the Chicoutimi Pulp Co. and for Price Bros. Co., Ltd. Estimated cost $1,800,000. O. LeFebre, 59 Notre Dame St., E., Montreal, Engr.

CONTRACTS AWARDED

Cal., Marysville—The Yuba Development Co., Hobart Bldg., San Francisco, awarded the contract for constructing arch dam, including raising present dam from 45 to 175 ft. in height, enlarged dam to be 500 ft. long on crest, 41 ft. thick at base and 6 ft. thick at top and power house, to Brent Bros., 1714 Eagle Ave., Los Angeles, $330,680 and $12,794 respectively.

Cal., Palo Alto—The Leland Stanford, Jr., University awarded the contract for a 2 and 3 story dormitory, to G. Wagner, 251 Kearny St., San Francisco, percentage basis, approximately $400,000.

Cal., San Francisco—R. L. Dunn, care J. R. Miller, Archt., Lick Bldg., awarded the contract for a 17 story office building on Sutter and Powell Sts., to P. A. Palmer, Monadnock Bldg., about $1,500,000.

Cal., San Francisco—G. D. Smith, 735 Taylor St., awarded the contract for a 10 story hotel and store building on Sutter St., to the Clinton Constr. Co., 140 Townsend St., $450,000.

D. C., Wash.—The U. S. Engineer's Office, 2802 Munitions Bldg., awarded the contract for a motor driven air compressor to the Norwalk Iron Works Co., Water S. N., Norwalk, Conn., $14,370.

D. C., Wash.—The U. S. Engineer's Office, 2802 Munitions Bldg., awarded the contract for Diesel engine, generating sets and switchboard, to the Winton Engine Works, 2116 West 106th St., Cleveland, Ohio, $121,498.

Ind., Indianapolis—The Bd. Sanitary Comrs., City Hall, awarded the contract for a power plant in connection with sewage disposal plant, to the W. P. Jungclaus Co., 825 Massachusetts Ave., $118,750.

Ind., Indianapolis—E. G. Spink & Co., Hume Mansur Bldg., will build a 6 story, 145 x 217 ft. apartment building on 16th St. Estimated cost $400,000. Work will be done by day labor. Noted Dec. 13.

Ind., Terre Haute—The Wabash Apartment Co., c/o J. D. Palmer, Archt., McKeen Bank Bldg., awarded the contract for a 4 story, 82 x 140 ft. apartment building to the North-Raffin Constr. Co., 914 Chestnut St. Estimated cost $400,000. Noted Aug. 15.

Md., Annapolis—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded the contract for additions to refrigerating plant at the Naval Academy Hospital, here, to the Clothel Refrigerating Co., 61 Bway., New York, $1,950 (30 days). Noted Aug. 15.

Mich., Grand Rapids—The Kent State Bank awarded the contract for a 13 story, 67 x 154 ft. bank and hotel, on Monroe and Ionia Aves., to Owen Ames & Kimball, Michigan Trust Bldg. Estimated cost $1,000,000. A steam heating system will be installed.

Minn., Detroit—The city, E. J. Bestick, Clk., awarded the contract for power plant equipment, consisting of 1 steam engine driven generating unit, of 300 kva. capacity; one 250 hp. water tube boiler and stokers for same, to J. G. Robertson, 2542 University Ave., St. Paul, $30,665. Noted Aug. 1.

Minn., North St. Paul—The city, J. A. Bender, Clk., awarded the contract for extensions to waterworks and electrification of pumping plant, including 36 000 lin. ft. c.i. pipe, hydrants, valves, specials, etc., to J. J. Connolly, 1007 Reaney St., St. Paul, unit price basis about $50,000. Noted Noted July 4.

Minn., St. Paul—F. H. Tandy, Brinsmeade Apts., representing owners, awarded the contract for a 16 story, 99 x 112 ft. hotel, including steam heating system, on St. Peter St., to Smith & Vandanaker, 501 Exchange Bank Bldg., cost plus basis, $1,600,000.

Minn., West Concord—The city, W. E. Glarner, Clk., awarded the contract for waterworks improvements, (1) steel tower and tank, to the Minneapolis Steel & Machinery Co., 2854 Minnehaha Ave., Minneapolis, $6,989; (2) pump house and removing present building, shaft extensions and pulley for present pump, etc., to F. E. Wright, $2,950. This is a part of waterworks improvement project estimated to cost about $35,000. Noted Aug. 8.

N. Y., Astoria—The Bd. Educ., 500 Park Ave., New York, awarded contract for P. S. No. 70 on 12th Ave., to J. MacArthur Co., 22 Ormond Pl., Brooklyn, $597,000.

N. Y., New York—The 49-53 West 45th St. Corp., c/o Sommerfeld & Steckeler, Archts., 31 Union Sq., will hold an office building on West 45th St. Estimated cost $350,000. Work will be done by separate contracts under supervision of architects. Noted Apr. 26.

N. Y., Niagara Falls—The Bd. Educ. awarded the contract for installation of heating and ventilating equipment in a new high school addition, to the Matthews Plumbing & Heating Co., 2107 Main St., $73,225.

N. Y., Syracuse—The Syracuse Hotel Corp., Gurney Bldg., awarded the contract for an 11 story hotel on Harrison and Warren Sts., to the Amsterdam Bldg. Co., 138 East 44th St., New York. Estimated cost $2,500,000. Noted July 4.

N. C., Charlotte—The Citizens Hotel Co. awarded the contract for electrical, heating and plumbing work, also mechanical equipment, for 12 story hotel, to Grinnell Co., Inc., 1 Liberty St., New York, $148,000. Noted July 25.

Ohio, Akron—The Bd. Educ., I. M. Moses, Clk., awarded the contract for a 2 story, 160 x 200 ft. grade school known as the King School, on Tallmadge Ave., to the Akron Storage & Constr. Co., Herberick Bldg., $194,000; heating and ventilating to the Kraus Plumbing Co., $40,000.

Ohio, Cleveland—The J. L. Free Co., 1004 Prospect Ave., awarded contract for an 8 story, 100 x 123 ft. apartment building, including steam heating system, at East 89th St. and Carnegie Ave., to the Crowell & Little Constr. Co., 3751 Prospect Ave. Estimated cost $400,000.

Ohio, Cleveland—The Morelease Co., c/o J Laronge, 214 Williamson Bldg., awarded the contract for 1 story theatre, 3 story, 50 x 200 ft. store and office building and a 4 story apartment building at East 105th St. and St. Clair Ave., to W. F. Thompson & Son Co., 5103 Euclid Ave. Estimated cost $310,000. Steam heating systems will be installed.

Pa., Greenville — H. E. McConnell, c/o Chamber of Commerce, has purchased a 35 acre site and will build a steel plant, including foundry, cold drawing mill, 4 rolling mills, one 500 ton blast furnace, etc. Estimated cost $2,500,000. Architect not announced. Quotations wanted on machinery and equipment.

Pa., Johnstown—The Bd. of Educ. awarded the contract for a 1 story, 110 x 115 ft. and an 80 x 242 ft. gymnasium and auditorium, to Thiel Constr. Co., Johnstown. Estimated cost $650,000.

Pa., Phila.—The Church of Incarnation, c/o R. J. Brady, awarded the contract for a 2 story, 47 x 359 ft. church and 79 x 159 ft. rectory on 52nd St. and Lindley Ave., to D. W. O'Dea, 5227 North 5th St. Estimated cost $500,000.

Pa., Phila.—The Lutheran Publishing Co., 9th and Sansom Sts., awarded the contract for an 8 story, 74 x 117 ft. printing plant at 13th and Spruce Sts., to Wark & Co., 231 South Broad St. Estimated cost $500,000.

Pa., Phila.—Phila. Electric Co., 10th and Chestnut Sts., awarded the contract for a 1 story, 59 x 121 ft. sub. station on American and Susquehanna Aves., to F. L. Hoover & Sons, 1023 Cherry St. Estimated cost $80,000.

B. C. Marpoli—The Pacific Meat Co., 268 Columbia St., Vancouver, will build a 2 story, 65 x 100 ft. abattoir and cold storage packing plant, etc., here. Estimated cost $80,000.

Ont., Kincardine—The Bd. Water Comrs., H. Hurdon, Chn., awarded the contracts for the slow sand filter equipment, as follows: tubes, National Iron Corp., Ft. of Cherry St., Toronto; pumps, Goldie McCulloch Co., Ltd., 64 West Main St., Galt; sewer pipe, Clay Products Agency, 9 Wellington St. E., Toronto; valves, T. McAvity & Sons Ltd., 95 King St. E., Toronto; sand washer, John Ingles Co., 14 Strachan Ave., Toronto; gasoline tanks, S. F. Bawser Co., Ltd., 66 Fraser St., Toronto. Estimated cost $60,000. Noted June 27.

Ont., Leaside—The Durant Motor Co. of Canada, 909 Royal Bank Bldg., Toronto, awarded the contract for an automobile factory consisting of five buildings, 1 story, 40 x 100 ft., 3 story, 80 x 401 ft., 3 story, 100 x 401 ft., 1 story, 20 x 200 ft. and 1 story, 130 x 500 ft., including steam heating systems, to N. McLeod, Kent Bldg., Toronto. $750,000. Noted Aug. 1